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New Developments To Feature Chicago Exhibit

PLANS are nearing completion for the exhibition of foundry equipment to be held at the Stevens hotel, Chicago, April 8-11, in connection with the annual convention of the American Foundrymen's association. Reports from A. F. A. headquarters indicate that all available floor space in the large exhibition hall, which has

View of an interesting exhibition recently held in the Stevens hotel, Chicago

been incorporated as a part of the world's largest hotel, has been taken by exhibitors. More than 140 individual manufacturers of equipment and supplies will maintain exhibits. These exhibits will be devoted to the latest developments in foundry equipment. The limited available exhibition space necessitates a careful selection of equipment to be shown. For that reason, manufacturers will pick those items that show the greatest progress made during the past year. The technical program, recently announced in THE FOUNDRY, contains a number of interesting papers which with the attendant discussion will present valuable information to the industry. Other activities which have been planned for the week include the annual exhibitors' dinner on Monday night and the annual banquet of the association on Wednesday evening. Special entertainment will be provided for the ladies; many of the leading foundries in the Chicago district will be open for inspection by convention visitors; and arrangements will be made for those who wish to play golf.

CONTENTS

FEATURE ARTICLES

Page

Automobile Foundry Pours Aluminum Castings on a Conveyor—By Pat Dwyer 222

Will Shrinkage Test Show Pig Iron Quality?—By E. J. Lowry .. 228

Describes the Manufacture of Manganese Steel—By H. P. Evans and A. F. Burtt 231

Melting Iron in the Cupola—Part XIV—By J. E. Hurst 234

Heat Treating Improves Physical Properties of Carbon and Alloy Steel—By J. Edward Donnellan 238

Measure Temperature of Molten Cast Iron—By H. T. Wensel and W. F. Roeser 245

Bill Learns Something New About Pigs—By Pat Dwyer 249

Large Casting Is Made in English Foundry 253

REGULAR DEPARTMENTS

How and Why in Brass Founding — By Charles Vickers 243

Readers Comment 244

Queries on Foundry Practice 252

The Shakeout 254

Trade Trends in Tabloid ... 255

Comings and Goings of Foundrymen 256

What the Foundries Are Doing 260

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Automobile Foundry

Pours Aluminum Castings On a Conveyor

By Pat Dwyer

FOR many years the Packard Motor Car Co., Detroit, operated a fairly commodious aluminum foundry in one section of a building devoted principally to the production of molds and cores for gray-iron castings. The coremaking department served as a neutral territory for dividing the two foundries. It was a convenient arrangement. The great bulk of the cores was absorbed by the iron foundry, but a considerable volume also found its way into the aluminum foundry. Increased production coupled with the erection of a continuous type core oven described at length in the Dec. 15, 1928 issue of THE FOUNDRY, recently placed a severe strain on the capacity of the aluminum foundry and as a result the company decided to build a complete new unit for the production of its aluminum castings. This decision took due cognizance of the advantages and disadvantages of the existing aluminum foundry, of the many forward steps that had been taken in the industry in recent years, particularly in the utilization of mechanical equipment, and the necessary steps were taken to provide a new foundry not only up to the minute, but in a few instances, a lap or two ahead of the procession.

Production schedules had to be maintained during the transi-

Fig. 1—The ladle holds sufficient metal to pour two crankcase castings

Fig. 3—The group of men in the background keep a constant supply of green sand cores on hand for crankcase molds

Fig. 2—Oil pan and foot board castings are made on the south conveyor

tion period. Therefore, the new unit gradually was eased into a full time program. All the equipment is new with the exception of the molding machines. These were moved from the first shop and installed in the second in suitable positions to function as integral parts of the new assembly. Several minor adjustments have been made since operations commenced a few months ago and one or two others are in contemplation before those in charge will be satisfied that no further refinement is possible, desirable or necessary. In the main, the change is considered a decided success and the minor adjustments referred to are of the character which accompanies the first operation of nearly every machine and certainly every plant where new ideas are tried out on a practical basis for the first time.

The building of steel, brick and glass constitutes an 80 x 176 foot extension to the former aluminum foundry, which now with the partition or end wall removed, serves as a general storage for miscellaneous supplies and equipment. The actual floor space in the new foundry is no greater than that in the old shop, but the tonnage produced already is considerably greater and can be increased still further without overtaxing either the molding or melting equipment. A concrete floor facilitates the transportation of miscellaneous material by truck. Light and ventilation are provided by swinging sashes in a sawtooth roof which corresponds to the style of roof over the entire group of foundry buildings.

Principal features of the new foundry include two conveyor units on which all the molds are assembled and poured, a complete sand handling outfit which prepares the sand and keeps it in circulation, an extensive monorail system for handling the metal and molds, two large reservoir furnaces and six tilting pot furnaces.

The National Engineering Co., Chicago, designed, fabricated and installed the greater part of the equipment in this foundry. This includes the two mold conveyors and the extensive sand collection, preparation and distribution equipment with the accompanying hoppers, belts and tunnels under the floor.

The general layout, also some of the details of the conveyor and sand handling equipment are shown in the illustration Fig. 11. The upper conveyor unit 25 x 96 feet is devoted to the production of floor plates and oil pans for Packard eight cars. Molding machines made by the Osborn Mfg. Co., Cleveland, and the Tabor Mfg. Co.,

Fig. 4—Metal from each reservoir melting furnace is tapped through three spouts into a battery of three pot furnaces

Philadelphia, are arranged in a straight row under a series of sand hoppers. Molds from the three drag machines are lifted by hand or by hoists, depending on the weight, to the moving conveyor and the cope parts of the molds are lowered into position during the period the molds are passing opposite the cope machines. The oilpan casting is molded in a position that the pattern leaves its own green sand core on the drag.

The conveyor is the plate or platform type. A number of cast-iron plates are attached to a chain which is driven by a 7½-horsepower motor mounted on a platform at the lower left corner of the conveyor as is shown in the illustration. Power is transmitted directly through a worm gear reducer to the vertical shaft extending down and through the sprocket wheel. The cast-iron shoes on the bottom of the plates slide on greased rails it is claimed without vibration.

An elevated grating platform extends across the right end and part way down the lower side of the conveyor for the convenience of the men handling the ladles and pouring the metal into the moving molds. The melting furnaces are located close to this end of the conveyor so that practically no change in temperature takes place in the metal from the time it is received in the ladle until it is poured into the waiting molds. Furnace practice and temperature control will be taken up later.

After the molds are poured they travel to a point in the center of the left or far end of the conveyor as it is shown in Fig. 11. Here they are dumped over a grating in the floor. The comparatively light castings are forked by hand into trucks and taken to the cleaning room. The drag flasks are placed on the main conveyor which carries them to a position in front of the drag molding machines. Here they are lifted off and once more utilized to form the drag halves of the molds. The copes are placed on a gravity roller conveyor on the opposite side of the battery of molding machines. This conveyor delivers them to the men who operate the cope machines.

The sectional view *AA* Fig. 11 shows how the sand is prepared and distributed to the conveyor, unit, also how the used sand is collected and once more placed in circulation. Sand from the shakeout falls through a grating upon a long belt running in a tunnel in the floor and extending to the boot of an elevator at the opposite or west end of the building. Excess sand, spilled around the molding machines falls through gratings in the floor upon the same long belt and is carried to the same destination. An overhead belt fills the storage tanks over the various machines in this unit.

Sand from this main belt may be deflected to a cross belt which in turn delivers it to a second longitudinal belt located above the center of the second conveyor unit. One longitudinal belt and two transverse belts located in suitable tunnels, carry the shakeout sand and excess sand from the molding machines, back to the main belt leading to the sand preparation station. Thus the sand for the complete operation of the foundry is under complete control at one central point, the sand preparation plant shown at the upper right in the general arrangement Fig. 11. Also shown immediately below in section *AA*.

Due to the comparatively light section of metal in the castings and the low temperature (1250 degrees Fahr.) at which the aluminum alloy is poured, the sand in the molds is not burned. The molds are shaken out in such a short time after they are poured that the greater part of the moisture remains in the sand thus the work of reclaiming and preparing

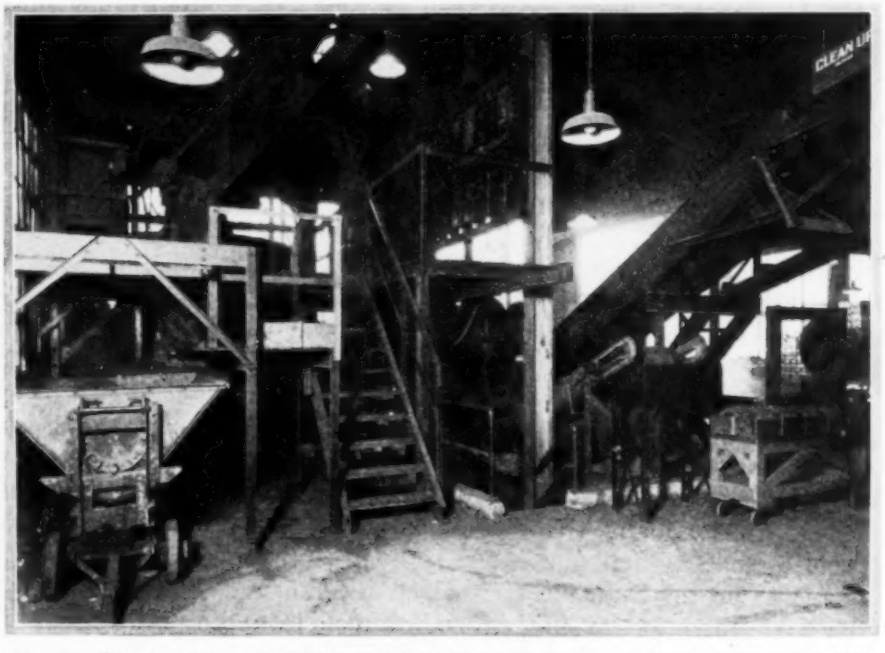


Fig. 5—The truck on the left receives the refuse from the sand preparation installation. Metallic inclusions in the sand are taken from the main conveyor belt under the floor

the sand is simplified to a great extent.

The main return belt discharges the sand into the boot of an elevator. All metallic inclusions including the numerous chills employed freely on these castings, are captured by a magnetic pulley and dropped upon a second belt running in the opposite direction which discharges them on to the special table shown to the right in Fig. 5. An attendant at this table sorts the material and distributes the various items into small steel containers which later are taken to the molding stations.

From the boot of the elevator the sand is taken to the highest point in the assembly and discharged upon a screen which catches all foreign and nonmagnetic materials which escape the magnetic pulley. The rubbish flows down through a chute shown to the upper left in Fig. 5 to a screen where a further examination removes anything worth while. The core lumps and other useless materials are collected in the dump truck shown in the illustration and sent away with other refuse.

Sand near the top of the tower falls through the screen into a large hopper and later is fed as required into an 8-foot pan where it is blended thoroughly under a pair of revolving rollers. This is the central feature of the sand handling equipment made by the National Engineering Co., Chicago, a circular pan in which the sand is subjected to a mulling action for a short period under a pair of hard iron rollers which may be adjusted at various heights from the bottom of the pan to suit conditions.

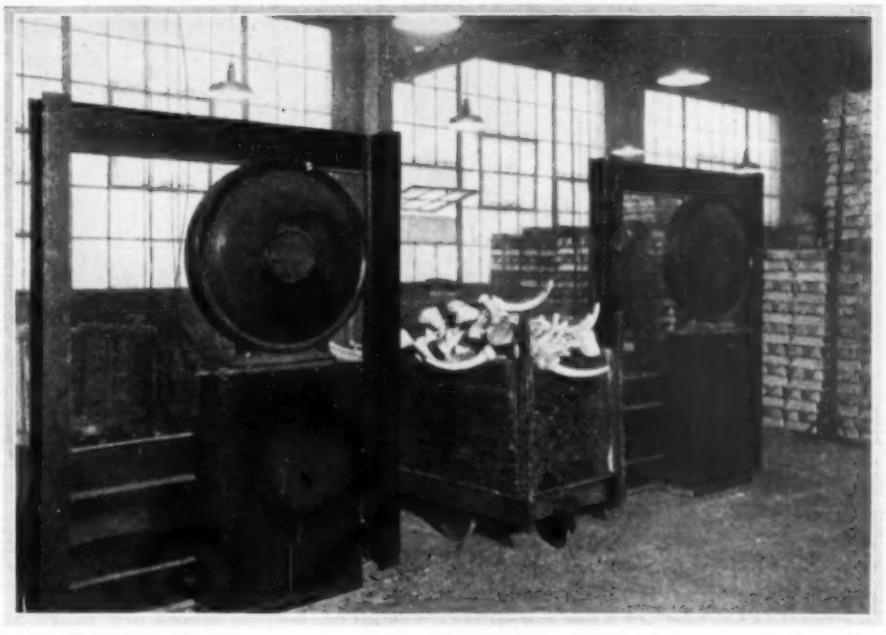


Fig. 7—Metal charges are made up in steel buckets resting on a scale platform in a pit below the floor level

The mulled sand is discharged from the pan on to an aerator, a revolving drum provided with a great many projecting knobs which aerates the sand before it falls on the main belt which carries it toward the two molding units. An elaborate system of individual control for the various parts of apparatus is centralized in a large switchboard mounted on the same platform which supports the muller and shown in the center of the illustration Fig. 6.

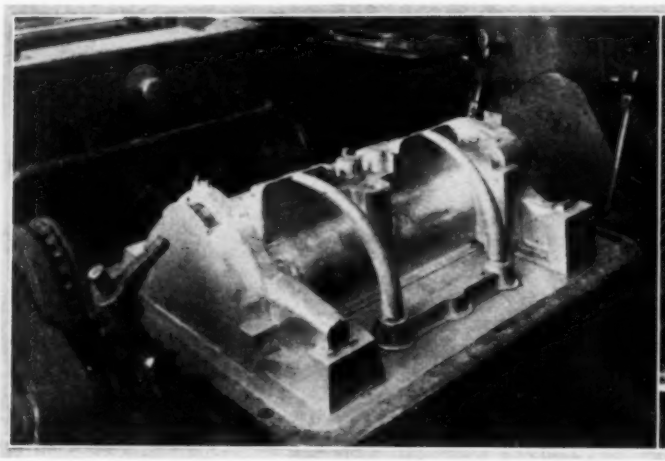
Incidentally it may be mentioned that a control station has been provided near each end of each conveyor unit. With this ready means at hand the progress of the conveyor may be checked as often as necessary during the day's operation. Even under the most favorable conditions an emergency stop sometimes is necessary.

The conveyor unit for making crankcase molds is shown in plan and section in the lower part of the illustration Fig. 11. The molding machine arrangement differs to a slight extent from that in the other unit. Drags are molded on three jolt, roll-over, pattern draw machines made by the Osborn Mfg. Co., Cleveland. The copes for these drags are made on two jolt machines supplied by the Tabor Mfg. Co., Philadelphia. One of the drag machines is fitted with a crankcase pattern for the custom and de luxe cars. The remaining two are fitted with crankcase patterns for the standard eight car which has a motor slightly smaller. The drag machines are located close to the east end of the conveyor where each one is supplied with sand from an individual storage hopper overhead. The two cope machines occupy a position close together near the west end of the conveyor and are supplied with sand from a breeches or twin hopper. All hoppers are equipped with gates controlled by short handles dangling within reach of the operators.

Short lengths of monorail with pendent air hoists facilitate the removal of the mold parts from the machines to the conveyor plates. Other hoists mounted in a similar manner are employed for shaking out the molds and loading the empty flasks for return to the various molding stations.

A double-deck gravity roller conveyor extends from the shakeout sta-

Fig. 6—Side view of the lower part of the installation where the sand is reconditioned. The back of the switchboard is shown in the upper center of the illustration



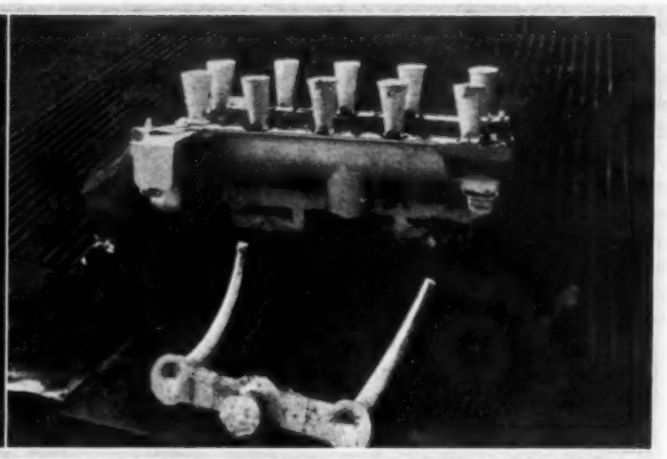


Fig. 8—Two horn gates constitute part of the pattern equipment. Fig. 9—The crankcase castings are shaken out over a grating

tion to a point close by the cope machines. The cope is lifted from the casting and shaken out over a grating, then placed on the upper or lower deck of the gravity conveyor, depending on whether it is for a small or a large crankcase flask. The drag containing the casting then is lifted from the mold conveyor and rolled over on a second grating shown in Fig. 9. The casting remains on the grating, the sand falls through upon a belt which takes it to the main return belt of the sand handling system, and the empty drag flask is placed on a short transverse gravity roller conveyor which takes it within reach of the air hoists serving the three drag making machines. An attendant knocks the runners and the numerous risers from the casting with a hammer. The gates and risers are collected and loaded for transportation to the metal storage department at the extreme west end of the building. The casting is placed on a long roller conveyor which carries it past the row of chippers and grinders standing on either side. Wire screens prevent the chips from flying too far. The maximum load on the crankcase conveyor during full time operation is approximately 30,000 pounds made up of poured molds empty molds,, half molds, empty and loaded plates and the weight of the chain itself. The conveyor unit has accommodation for 32 flasks, but usually a series of empty plates varying from six to eight, intervene between the shakeout station and the southeast corner where the first drag is dropped into place.

Flasks, bottom plates and copes are aluminum, but the conveyor plates are cast iron. Bottom plates on all molds are perforated freely to afford ready escape of gas and steam generated during the pouring operation. Joints are machined to a true fit and all flasks are interchangeable. One guide pin at each end guides the cope into place on the drag. Guide pin holes are equipped with hardened steel bushes which are removed and replaced when they show signs of wear.

Crankcase castings are poured through two horn gates as shown in Fig. 8, a pattern and gate in place ready for the drag flask. A single sprue in the cope delivers metal to the horizontal member connecting the two horns.

After the sand is rammed in the drag, a bottom plate is adjusted in position and held in place by four ingeniously air-operated clamps while the drag is elevated and swung through an arc of 180 degrees. The arms of the machine hold the table and pattern in this position while a second table takes the weight of the drag and lowers it away from the pattern. The table and pattern then are swung back to the original position to receive another empty drag, while the completed drag is lifted by an air hoist and placed on one of the conveyor plates. The sequence is continued throughout the entire working period. All the cores are placed in the drag while in transit between the drag and cope making stations. With the exception of a dry sand long slab core along one side and the dry sand gear housing core at one end, also a few small special dry sand cores, the mold is filled with green sand cores which touch each other to form the interior of the crankcase. Each individual core rests on a print in the bottom of the mold, a continuation of the piston rod opening in the casting. Green sand presents many advantages for cores, chief of which is the facility with which it collapses when subjected to the contracting force of surrounding metal. A crankcase casting with its numerous openings, brackets

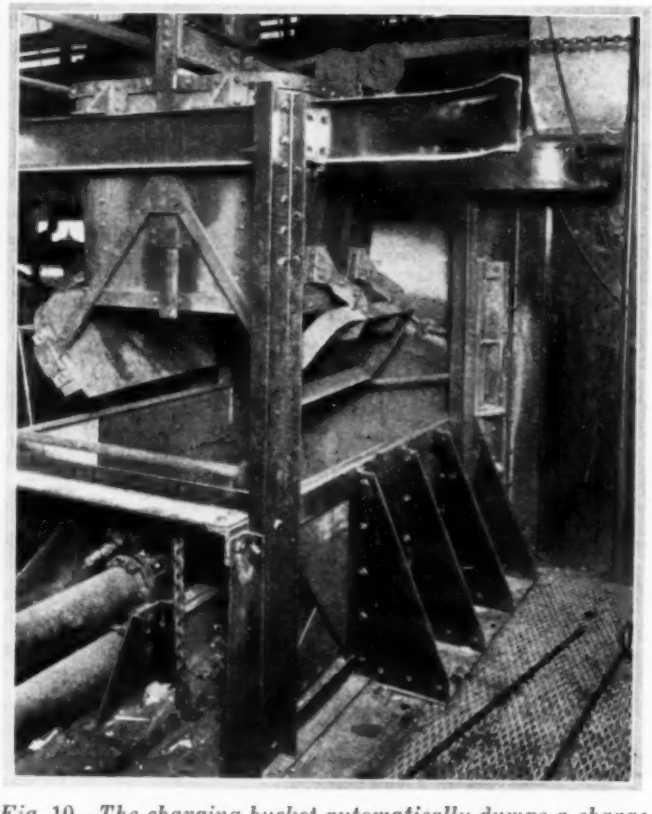


Fig. 10—The charging bucket automatically dumps a charge into a box from where it is pushed into the furnace

and comparatively thin metal section represents a real hazard from cracks, draws and shrink holes when poured around an unyielding dry sand core. The green sand core removes practically all hazard.

At present the cores for the day's operation are made in detachable metal coreboxes by a group of men working at a long bench in the center of the conveyor space. The management is experimenting with a machine which blows the sand into the box under air pressure and expects in the near future to replace 16 men with a group of 6 men and 6 machines. Cores are placed in the molds after the manner that has become standardized in foundries where the molds are constantly in motion. One man sets the small, dry-sand cores. A second drops the green sand cores in place with the speed and skill due to long practice and a third man tries the cores with a gage and gently pinches the joint together at the top. This practically converts the various units into one continuous core, also prevents the metal from forming fins at the joints.

To meet present operating conditions, the crankcase conveyor is geared to make three complete revolutions per hour. The driving mechanism may be adjusted to accelerate or retard this speed to synchronize with production schedules.

Metal is melted and then held in a molten condition in a pair of rectangular, oil-fired furnaces elevated 6 feet above the floor level. It is tapped regularly into a battery of six tilting pot furnaces, made by the Bellevue Industrial Furnace Co., Detroit, three in front of each reservoir. The molten aluminum remains in each pot for approximately 10 minutes where it is raised by an oil flame to the proper pouring temperature. A recording pyrometer in each pot is connected to a signal board with white, red and green electric light bulbs. The green light signifies that the metal in that particular pot represented by the light, is too cold. The white light tells the furnace attendant that the metal is just about ready to tap. The red light warns the melter that the temperature of the metal is approaching the upper safety range and either must be poured immediately, or the oil burners under the pot must be shut off.

Each of the pot furnaces is tipped with a hand wheel. In each group of three, the two outer furnaces are equipped with the usual style wheel set close to the shell. The center furnace in each battery is operated through a shaft extending to a point slightly beyond and back of the wheel on the outer furnace. The oil and air valves for the burners are set close to the bottom of the furnace within convenient reach of the attendant.

The pots are kept at a red heat all day and as a result the life of these castings has been increased from 75 to 250 heats. Formerly they were subjected to alternate heating and cooling due to the periodic introduction of cold metal. Now the pots are replenished regularly with molten metal from the two large reservoir furnaces located above and slightly back of the pot furnaces. Each of the reservoir furnaces is equipped with three spouts through which the metal is tapped into the pots. From the pot the metal, properly conditioned as to temperature, is emptied into the pouring ladle. Pot and ladle are of equal capacity, 350 pounds, sufficient to pour two crankcases.

The method of handling the molten metal is shown in Fig. 1 where a ladle is suspended from a monorail hoist that serves the battery of furnaces and the mold conveyor. The operators stand or walk on a platform adjoining the mold conveyor and continue pouring the metal while the molds are in motion. This part of

(*Concluded on page* 230)

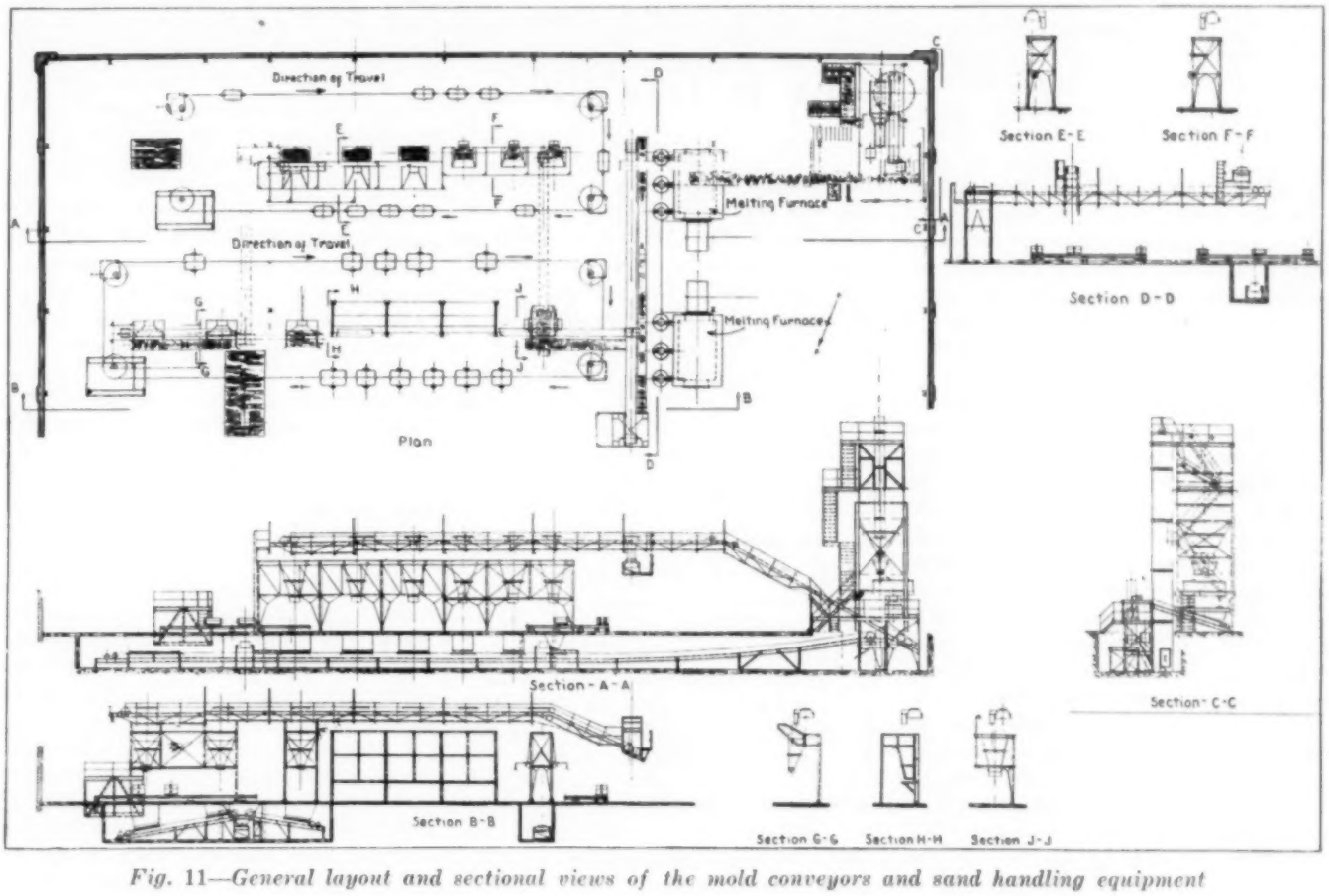


Fig. 11—General layout and sectional views of the mold conveyors and sand handling equipment

Will Shrinkage Test

Show Pig Iron Quality?

Blast Furnace Practice Influences Quality of Pig Iron and Bears Some Relationship to Shrinkage Encountered in Castings

BY E. J. LOWRY

INTEREST in the quality of pig iron dates back to about 1917, when casting troubles increased above normal. A few foundrymen investigating the causes of these troubles, seemed to trace at least a few of them to the pig iron in their mixtures.

The method of investigation was to eliminate one factor after another and to watch results. By this method, one brand of pig iron would be removed from the mixture. If the troubles in the foundry vanished, the pig iron was at fault and this brand condemned. This was far from satisfactory because pig iron was scarce and the foundrymen often were forced to return to the condemned brand, only to find that with the reintroduction of this material no real trouble was experienced.

Foundrymen during the past ten years, have learned that scrap was being used in the blast furnace. Many foundrymen had tried to lay the blame on the use of scrap in the manufacture of pig iron. However, at the present time there is no real authentic information which might prove that scrap in pig iron manufacture decreases the quality of the product.

Many papers have been written during the past three years on the subject of scrap and its effect upon the quality of the pig iron manufactured. Two papers on this subject were presented by McKee and by Moldenke. The paper by McKee presented the blast furnace side and tended to prove that scrap used in the blast furnace had no harmful effects on the product. The one by Moldenke gave evidence that the quality of pig iron had decreased during the past ten years and it intimates that the use of scrap might be one of the causes. Some foundrymen claim they can use any kind of pig iron and accomplish good results, whereas others maintain that they must have the highest quality pig iron to produce castings satisfactorily and specifically state that it must be made with all virgin ore.

Various technical associations in the United States are trying to solve the problem of quality of pig iron.

Gives American View

THIS article is abstracted from a paper which was presented in behalf of the American Foundrymen's association at the annual meeting of the Association Technique de Fonderie de Belgique. E. J. Lowry, the author, is a foundry consulting engineer, Detroit.

Some of these organizations already have met and passed resolutions to obtain some real facts surrounding this material. This will be slow and tedious work, because some method of measuring the quality of pig iron first must be found. If such a measure can be determined, then the next step will be to apply it to the manifold conditions existing in a blast furnace.

Numerous suggestions have been propounded to measure this quality, such as the remelting of a small part of the cast at the furnace from which test bars are poured and the physical property tests determined on these bars. A second method which has been suggested is the use of brinnell hardness test to determine quality. The method of dilatation also has been suggested. The latter method seems to hold some merit, although the investigational work has not been carried far enough to draw any positive conclusions. The work of Fremont and Portevin along these lines gives some interesting features.

Dilatation seems to show that any abnormality in the pig iron changes the characteristics of the curves. These curves show an apparent difference between the different brands of iron manufactured in the United States. Pig irons from 27 blast furnaces located in various parts of the United States have been investigated by this method, and no similarity can be found in the curves. Consecutive casts from one furnace anaylzed by this method shows a similarity in the curves obtained. It appears that with pig iron of an inferior quality, dilatation is increased, but the main characteristics of the curve are retained.

Dilatation further proves that pig iron influences the product made from its mixture with other materials. A piece of casting made from a mixture of pig iron and scrap and tested by this method will show the salient characteristics of the curve obtained from the pig iron. This bears out many statements which have been made regarding the influence of pig iron on the casting. These data also tie in with the work of Piwowarsky and other investigators working on high temperature casting practice, because when pig iron and scrap are melted in electric furnaces at high temperatures, the dilatation curve of the casting has no apparent relation to any of the curves of the materials used in the mixture.

Use of the brinell machine in investigating the quality of pig iron was discussed by the late Jesse L. Jones. There seems to be some merit to this mode of investigation. However, so many vagaries enter into this test, that it is felt it would have to be used in specific instances where all other conditions were known. As

an instance ,the size of the pig would influence the hardness. If the pig metal boiled in the mold of the casting machine, hard spots would be bound to result throughout the mass of the pig iron. Again, if the pig metal was cast cold, the movement of the casting machine apparently disturbs the solidifying metal, causing dense spots to be prominently distributed throughout the mass of each pig. The method of testing pig iron at the blast furnace for quality has so far received slight attention. Therefore, the possibilities of such a test are unknown.

An old method of testing and which seems to have been discarded by foundrymen is Keep's shrinkage test. This test has never been considered in determining quality of pig iron, and yet it has some possibilities. Almost everyone is familiar with the procedure of this test, so it is unnecessary to present a description. In a recent investigation, the figures obtained indicate the possibilities.

Performs Experiments

The accompanying table gives a list of 24 pig irons which with their shrinkages, was obtained in two sets of tests run separately by two different investigators. The figures under pig iron and castings were the result of the author's investigation. The figures under crucible test were determined in one of the largest foundries in New England. The author's test shows figures from ten bars each from ten different casts. The crucible tests are the result of one bar. This may account for any wide discrepancy. The method of indicating the brands was chosen because Indian, Dutch and Continental irons as well as some domestic coke and charcoal irons are included.

Pig iron *M* in the table shows a wide discrepancy in the test figures. This is easily explained in that the pig iron used in the crucible test had been in the foundry yard since 1916, whereas the pig iron used in the other test was recently made. Apparently, something had happened in this one furnace which has changed the expansion or contraction of the iron.

In conjunction with this test, mixtures containing the pig irons were used in the cupola from day to day and the effect not only on Keep's test but also on the actual castings was watched. It was found that as the mixture varied the shrinkage changed automatically. In the case where pig iron *M* from the 1916 cast was used, shringage was low. As pig iron *M* of the new cast was introduced, shrinkage increased to a point where many of the castings were not fit. This shows evidence that the Keep test gives some indication of the effect of the quality of pig iron on the castings.

A test was performed to show the effect caused by changes of pig iron in a mixture in relation to shrinkage. The mixture used was as follows:

Brand	Pounds
C	400
M	500
J	400
Shop Scrap	700

This mixture was run for six days. The test bar was poured at the same period in the melt each day. Pouring temperature was kept constant and variation in chemical elements was practically nil. Yet the shrinkage varied from 0.109 to 0.131.

Shrinkage Table

Brand	Pig Iron	Casting	Crucible
A	0.172	0.177	0.160
B	0.147	0.156	0.148
C	0.152	0.156	.....
D	0.144	0.147	.....
E	0.168	0.170	0.172
F	0.148	0.152	.....
G	0.146	0.151	.....
H	0.151	0.159	.....
I	0.174	0.180	.....
J	0.149	0.158	0.152
K	0.161	0.162	0.165
L	0.137	0.139	.....
M	0.144	0.147	0.129
N	0.141	0.143	.....
O	0.131	0.133	.....
P	0.138	0.139	.....
Q	0.138	0.140	0.146
R	0.127	0.130	.....
S	0.121	0.124	.....
T	0.136	0.138	.....
U	0.134	0.136	.....
V	0.133	0.137	.....
W	0.139	0.143	0.144

Shrinkage stepped up from the low on the first day to the high on the second day. The low shrinkage gave oversize castings, whereas with the high shrinkage the castings were at the maximum limit. The mixture was changed and pig iron *O* was introduced. The new mixture was as follows:

Brand	Pounds
C	200
M	400
J	400
O	400
Shop Scrap	600

This mixture was run for a period of six days and all the factors making the test bar were kept as constant as possible. The variation in chemical elements was normally the same as in the previous test, yet the shrinkage varied from 0.121 to 0.128. It would almost seem that pig iron *C* was the malefactor in this case, and that this brand required pig iron *O* to carry its burden.

Similar tests have been conducted throughout a period of a year. It was believed first that the relation of chemical elements caused the shrinkage to increase to as high as 0.154. Accordingly, the silicon was varied only to find that sometimes the low silicon iron gave lower shrinkage than the high, and vice versa; phosphorus was varied from 0.20 to as high as 0.90 with the conclusion that phosphorus had little effect upon stabilizing shrinkage conditions. Combined carbon did not offer the key to the solution and the same appeared to be the case in the other elements. Eventually, the conclusion was drawn that the relation of pig iron and scrap was the influencing factor.

Shrinkage Changes

One of the merchant pig iron producers had been investigating the question of quality of pig iron and its relation to the question of shrinkage. This happened to be the producer of pig iron *A*. He believed that a mixture containing 40 per cent of this brand, and 60 per cent shop scrap, would give a shrinkage in the test bar not over 0.125. The mixture was manipulated in accordance with his request. The result was, strange to say, that the shrinkage remained between 0.125 and 0.130. This same pig iron had been used prior to this test and the results were far from satisfactory. Shrinkage was always high and the foundry always had been unable to produce satisfactory castings. When the first car had been consumed, a second car was ordered. Using the same method of procedure in mixing the iron, the shrinkage on the first day was 0.145 and by the end of the week was back to as high as 0.154. The difference in these cars was traced and it was found that the only change in the furnace practice was a substitution of a different grade of ore. This might lead one to believe that the ore burdens in a blast furnace have an effect upon the quality of pig iron.

Another experiment which was performed during the latter part of the consumption of the first car of pig iron *A*, was to increase the percentage of pig iron and decrease the percentage of scrap. As the pig iron in the mixture was increased, the shrinkage increased. This same experiment was performed on other pig irons with similar results. One might conclude from this that there is a definite relation between the percentage of scrap and the percentage of pig iron in producing proper results. Another conclusion that might be drawn from these experiments, is that where two pig irons are placed in the mixture, there is a relation between the two pig irons and also the scrap in the mixture. In other words, each material seems to have a point of saturation for the other in obtaining the proper results.

It must not be concluded from the

reference to the effect of chemical elements on shrinkage that it is believed that they have no relation to this property. It is an established fact that white iron has a greater shrinkage than gray iron. What is meant in this instance is that in working from 2.20 per cent silicon to as high as 3.15 per cent silicon in the castings, we were unable to get positive results. In the case of the 2.20 per cent silicon this record was sometimes higher than in the test for the 3.15 silicon and vice versa.

Changes Affect Quality

It is only reasonable to feel that some of the great changes that have taken place in the manufacture of pig iron during the past twenty years have affected the quality. No doubt some influence is caused by mass production but more often any ill effects caused by such strides is offset by changes in furnace lines. The more probable solution to the changes in quality is either by the introduction of scrap in the blast furnace or by a change in ores. Fuel, too, seems to have a direct relationship to the production of pig iron in regard to quality. When any investigation is instituted, the materials used in burdening the furnace must be considered as well as the furnace practice.

Prof. R. S. McCaffrey presented a theory of the causes for the changes in quality of pig iron at the June, 1927, meeting of the American Foundrymen's association. This paper gives a concrete idea of what may happen during the reduction in a blast furnace. It is felt that not only does the question of temperature reduction affect the quality of pig iron, but also the condition and the analysis of the slag under which the molten pig iron must stay in the crucible of the blast furnace. One experiment in a coke furnace which had been working on a distinctly basic slag proved that the quality of the iron in this instance could be greatly bettered by running on either a neutral or an acid slag.

Results of this experiment were checked through the foundries to which the pig iron was shipped and without an exception the change in the blast furnace practice bettered the casting conditions. In another furnace the change from an acid slag to a basic slag increased the quality of the pig iron. Therefore, no one strict rule may be laid down because the ores, the fuel and the limestone entering the furnaces are all different. These differences must be taken into consideration and must be treated accordingly.

Pours Aluminum Castings on a Conveyor

(*Concluded from Page* 227)

the system constitutes an elastic link in synchronizing the speed of the conveyor with the delivery of the metal. Normally, the molds are poured while traveling across the comparatively narrow end of the conveyor. In an emergency the ladle men can follow a mold or molds along one side almost as far as the shakeout.

The temperature of the molten metal in the two special rectangular oil-fired reservoir furnaces built by the McCann-Harrison Co., Cleveland, is controlled automatically. So long as the temperature remains at or below 1250 degrees Fahr., the oil burners throw a full flame into the furnace. If the temperature shows a tendency to rise above that point an automatic check shuts off the supply of oil and air.

Charge the Furnace

Charges of remelt and ingot metal in the proportion of 60 and 40 per cent are loaded in two drop bottom steel buckets, placed for convenience in small pits in the floor back of two scales made by the Toledo Scale Co., Toledo, O. Although originally designed for 1000 pound charges, experience has shown that better results are secured with a standard charge of 600 pounds.

At the close of each day, the furnaces are drained and the bottom is cleaned. A night shift charges approximately 20,000 pounds of metal into each furnace before midnight. About 4 a.m. the molten metal is stirred thoroughly and treated with zinc chloride. The resulting scum is scraped from the surface of the metal, through an end door in the furnace, where it falls through a trapdoor in the platform and into a waiting receptacle. The metal is given a second similar treatment before pouring operations commence at 7 a.m.

The remainder of the 40,000 pounds is charged steadily in 600-pound lots until noon. In a general way it may be said that one charge is placed in the furnace bath throughout the forepart of the day, for each two potfulls that are tapped below. Charging ceases at noon, because at that time a sufficient amount of metal is contained in the furnaces to keep the pouring gang busy until quitting time.

The regular No. 12 aluminum alloy, 92 per cent aluminum and 8 per cent copper is used in the castings made in this foundry. The mixture also carries approximately 2.00 per cent silicon. Experience has shown that a slight silicon addition, greatly improves the quality of the metal and prevents cracks and draws. Also, the alloy with the silicon may be poured at a lower temperature without danger of coldshuts.

A common charging and observation platform serves the two reservoir furnaces. Space between the ends of the furnaces is occupied by two charging chutes. The loaded bucket is lifted by a small electric hoist from the pit back of the scale to a steel frame above the charging chute of the furnace. The bucket is lowered until the outside edges rest on the top of the steel frame. With the outside of the bucket at rest, the bottom flaps open downward and allow the contents to fall into the charging chute. An air cylinder pushes the contents of the chute through the charging door of the furnace. The air cylinders are mounted side by side horizontally. One pushes the load north into one furnace. The other pushes the load south into the second furnace.

Increases Membership

The Gray Iron institute has accepted the following companies as members of the organization: Gray Iron Foundry Co., Reading, Pa.; J. E. Gilson Co., Port Washington, Wis.; Blue Valley Foundry Co., Kansas City, Mo.; Weber Engine Co., Kansas City, Mo.; Security Stove & Mfg. Co., Kansas City, Mo.; Jno. C. Kupferle Foundry Co., St. Louis; Acme Foundry & Machine Co., Coffeyville, Kans.; Hubbard Portable Oven Co., Chicago; Northwestern Foundry Co., Chicago; Pyott Foundry Co., Chicago; Sheffield Foundry Co., Chicago; C. H. Milles Foundry Co., Chicago; W. A. Jones Foundry & Machine Co., Chicago; Semi Steel Test Foundry Co., Chicago; Nichol-Straight Foundry Co., Chicago; Ferguson & Lange Foundry Co., Chicago; Woodruff & Edwards, Inc., Elgin, Ill. and the Whiting Corp., Harvey, Ill.

Describes Properties

Recently the engineering experiment station, University of Wisconsin, Madison, Wis., published a bulletin describing the static and fatigue properties of some cast irons. The work was performed by J. B. Kommers and the results were given in a paper which was presented at the 1928 meeting of the American Society for Testing Materials at Atlantic City, N. J. The bulletin is Reprint No. 11 and is entitled, "The Static and Fatigue Properties of Some Cast Irons."

Describes the Manufacture of MANGANESE STEEL

By H. P. Evans and A. F. Burtt

PERHAPS the first mention of nonmagnetic iron-manganese alloys is by Rinman, who in 1774 observed that the white brittle metal obtained by fusing equal parts of gray pig iron and manganese oxide was not attracted by a magnet. About 1830 David Mushet prepared alloys containing up to 30 per cent manganese, using manganese oxide, iron oxide, cast iron, charcoal and a fluxing agent. He noted the nonmagnetic nature of the metal but apparently the carbon content was too high to give the properties later obtained by Hadfield. Considerable investigations of manganese additions were carried out by German producers and more especially at the Terre Noiri works in France about 1875. The reports of these investigations tended to show that steels containing much over 1 per cent manganese were brittle. The reports included an alloy of 11 per cent manganese content, but the carbon content was 2.42 per cent and the steel was brittle.

In the face of these and many other discouraging reports concerning manganese alloys Robert A. Hadfield in 1883 finally produced the alloy known throughout the world by his name—Hadfield steel or more commonly called manganese steel. This alloy has the following analysis:

Element	Per Cent
Carbon	1.00— 1.45
Manganese	10.00—14.50
Silicon	0.30— 1.00
Sulphur	0.01— 0.03
Phosphorus	0.04— 0.10

The ratio of the carbon and manganese contents is maintained at approximately 1 to 10. Hadfield published an exhaustive report in the *Journal*, Iron and Steel Institute of Great Britain in 1888. Hadfield first used the converter for the manufacture of manganese steel. He melted low-phosphorus, low-sulphur pig iron in a cupola and then blew it dead in a converter. Molten ferromanganese, melted either in a special cupola or crucible then was added to bring the heat to the proper analysis.

One of the chief difficulties encountered in this process was the inability to use old heads, gates, and other manganese scrap without the attendant loss of manganese due to oxidation during melting. Air furnaces were used to a certain extent, but many hundred tons of manganese scrap were piled away awaiting the discovery of a method of retaining the manganese content of the scrap. Advantage was taken of the so-called Swedish practice of blowing converter metal, whereby a portion of the heat developed during the blow is obtained from the manganese in the metal, thus utilizing the manganese content by using it as a source of heat. Improvement in cupola practice of melting ferromanganese by the use of a low blast, low coke ratio, etc., cut down the loss of manganese in the melting of ferromanganese. With all the improvements available, however, there was a considerable loss of manganese during the melting, and not until after the advent of the electric furnace was it possible to make manganese steel using manganese scrap without a considerable loss in the manganese content.

The manufacture of manganese steel by the open-hearth process was handicapped by the fact that it is impossible to refine a charge containing manganese steel scrap without the loss of much of the manganese due to oxidation. Hence all manganese steel made in the open-hearth has been made by ladle additions of ferromanganese. While it is possible to make excellent manganese steel by ladle additions of ferromanganese, and many tons of open-hearth manganese steel have given satisfactory service in industry, the inherent difficulties of this method and the opportunities for obtaining a nonuniform product are evident.

The first electric furnace melting practice used for manganese steel was similar to that used for carbon steel. A basic bottom was used because the basic manganese slag attacks an acid lining. Soft steel scrap was melted under an oxidizing slag

Authors Co-operate

THIS article is abstracted from a paper which was presented at the American Foundrymen's convention held at Philadelphia, May 14 to 18. H. P. Evans, one of the co-authors of the paper, was graduated from the University of Kansas, Lawrence, Kan., and received the degree of doctor of philosophy in physical chemistry and physical metallurgy from Iowa State college, Ames, Iowa, in 1925. Mr. Evans has served as metallurgist for the American Smelting & Refining Co., and as professor of chemistry and metallurgy at the Kansas State Teacher's college and Iowa State college. At the present time he is metallurgist for the Pettibone Mulliken Co., Chicago.

A. F. Burtt, the other co-author of the paper, was graduated from Beloit college, Beloit, Wis., in 1916, when he received the degree of bachelor of science in chemistry and metallurgy. He then spent one year at the Chicago Heights, Ill., plant of the American Manganese Steel Co., and for two years served in the World war. After being mustered out he was associated with the Electric Steel Co., Chicago, for a short time, and then spent three years as melter for the American Manganese Steel Co., Oakland, Calif. Mr. Burtt entered the employ of the Pettibone Mulliken Co., Chicago, in 1922 as a melter and at the present time is assistant foundry superintendent.

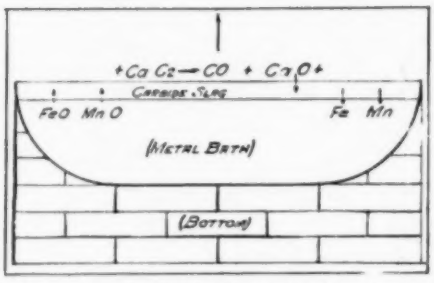


FIG. 1—DIAGRAM SHOWING DEOXIDIZING REACTIONS IN BATH

and the slag removed. A second slag was added and the heat finished under reducing conditions exactly as for carbon steel. Finally the required amount of ferromanganese was added, the bath brought to the proper temperature and tapped. Soon it was found that the ferromanganese could be added immediately after slagging off, but the subsequent practice remaining unchanged. A little later the ferromanganese was added immediately after the heat was melted and then the heat was finished under a single slag. Later full advantage was taken of the neutral atmosphere of the furnace during the melt-down and the reducing action of the carbide slag permitting the melting of ferromanganese and manganese scrap from a cold charge and finishing under a single carbide slag.

While it is possible in a general way to describe the present-day practice of melting manganese steel in a basic bottom electric furnace, specific conditions arise peculiar to manganese steel that necessitate careful operation and the employment of a responsible melter well acquainted with the peculiarities of manganese steel. Low-carbon, low-phosphorus steel scrap, manganese steel scrap and sufficient ferromanganese to bring the manganese content of the bath when melted almost to the specifications are charged cold into the furnace. The manganese steel scrap may range from none to practically 100 per cent of the charge. Power is turned on, using high voltage for melt-down in order to shorten the time of this operation. Since gases are being given off constantly from the burning of the electrodes there is at all times a pressure of gas out through the door and tap hole. Practically no air enters the furnace and any oxidation results almost entirely from the rust and oxides of the charge. It is due to this fact and to the presence of a carbide slag during the finish of the melt that manganese scrap and ferromanganese can be added with the initial charge in the electric furnace without the loss of manganese that occurs in the converter and open-hearth furnace. When the charge is melted the bath is stirred and a laboratory test is taken. Ferrosilicon is added, and lime, fluorspar and coke added to form a slag. The furnace is operated under a lower voltage in order to protect the refractories, and the refining operation begins. Necessary additions as indicated by the laboratory analysis then are made. If it is desired to raise the manganese without raising carbon, silicomanganese or low carbon ferromanganese are added. The bath is stirred vigorously and proper additions are made to form a carbide slag.

Calcium carbide is a strong deoxidizing agent. Deoxidation is accomplished as shown by the following reactions and as illustrated in Fig. 1.

FIG. 2—MANGANESE STEEL AS CAST SHOWING AUSTENITIC STRUCTURE WITH CARBIDE SEGREGATION ALONG GRAIN BOUNDARIES AND THROUGH THE GRAIN ITSELF

$$Ca\ C_2 + 3\ FeO = CaO + 2\ CO + 3\ Fe$$
$$Ca\ C_2 + 3\ MnO = CaO + 2\ CO + 3\ Mn$$

Since the CO is formed at the contact of the slag and bath, and not in the body of the metal, it is not absorbed and dissolved by the bath to an appreciable extent. The iron and manganese go back into the bath and the CaO into the slag. Fig. 1 represents the metal bath in the electric furnace with a covering of carbide slag and illustrates the above reactions. The carbide first reduces the easily reducible oxides of the slag. It then attacks the oxides dissolved in the bath. Due to the surging action of the bath and occasional stirring these oxides are removed from the bath; the metal from the oxide is returned to the bath and deoxidation is complete.

Calcium carbide is probably the most efficient desulphurizing agent known. Desulphurization is accomplished by the following reaction:

$$4\ CaO + 2\ CaC_2 + 3\ MnS + 3\ FeS = 6\ CaS + 4\ CO + 3\ Mn + 3\ Fe$$

Since the sulphur is naturally removed by manganese under a basic slag this additional removal brings the sulphur content down to almost a negligible point and sulphur ceases to be a problem.

The ferrosilicon acts as a degasifying agent as follows:

$$2\ CO + Si = SiO_2 + 2\ C$$

Ferrosilicon additions should be made early enough during the finish of the heat that time is given for the resulting silicon dioxide to separate from the bath.

The teapot ladle seems the most satisfactory type of ladle for manganese steel, though the tap ladle and lip ladle are used satisfactorily to some extent. Care must be exercised in controlling the pouring temperature of the metal. If poured too hot, excessive shrinkage and a cutting action in the mold most pronounced at the gated end are apt to occur. Large heads, gates and risers permit the pouring of the heavy jobs on the cold side. Light work is poured of hotter metal.

Manganese steel is not adapted for the wide range of analysis used in carbon steel. Different types of castings, however, do require somewhat different analysis. In general, heavy work, especially of irregular section, is poured from metal of less than 1.25 per cent carbon to obviate the liability of cracking during cooling. In some work where hardness is essential even with the sacrifice of some ductility the carbon may be raised to 1.40 per cent.

Shrinkage of manganese steel is considerably greater than that of carbon steel, so all patterns must be made accordingly. The shrinkage of carbon steel is not over ¼-inch per foot. While that of manganese steel is approximately ⅜-inch per inch. Because of this fact, and other factors peculiar to manganese steel,

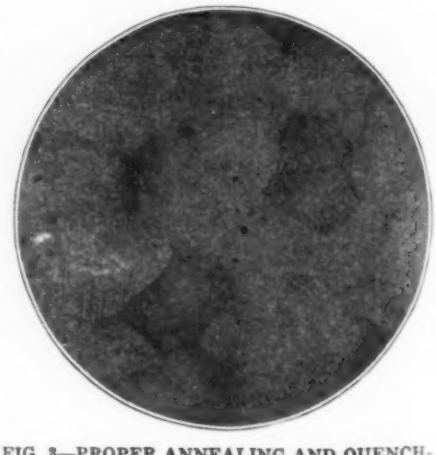


FIG. 3—PROPER ANNEALING AND QUENCHING DISSOLVES THE CARBIDE SEGREGATIONS

many unsatisfactory and weakened castings are turned out of foundries not thoroughly familiar with manganese steel through daily contact with it on the floor.

By the proper use of chills in the mold at the junction of two different thicknesses of metal, rates of cooling of the two sections can be controlled and cracking eliminated. After the castings are cooled sufficiently they are shaken out.

All railroad castings are relieved as soon as they are set. The gates and heads are dug out, bars bent and copes raised so that the castings may cool lying free in the drag.

Particularly difficult castings subject to undue stresses while cooling are shaken out hot and immediately placed in the annealing furnace and annealed without being allowed to become cool. Heads and gates which are to be broken off are removed before heat treating because they are too tough to be broken after the heat treatment. The larger heads and gates are burned off.

Heavy castings annealed in a car type furnace are brought to a temperature of 1600 degrees Fahr. and allowed to soak at this lower temperature to obviate the excessive oxidation that would occur by soaking at the quenching temperature. They are then brought to a temperature of from 1850 to 1925 degrees Fahr. and quenched in water. Smaller castings treated in a suitable furnace are quenched in water from the same temperature. After a sandblast the castings are ground to the proper finish and straightened, if necessary. The grinding department is an important part of a manganese steel foundry. Since the castings are too tough to be machined commercially, all finishing is done by grinding and elaborate grinding equipment is necessary to obtain the finish and close tolerances demanded by the customer. Soft steel inserts are cast in parts where machining is necessary.

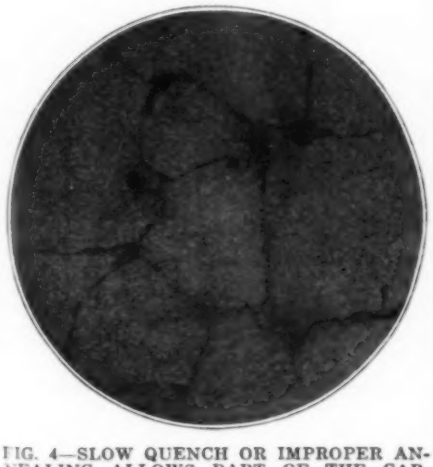


FIG. 4—SLOW QUENCH OR IMPROPER ANNEALING ALLOWS PART OF THE CARBIDE TO REMAIN UNDISSOLVED

Manganese steel is comparatively soft, registering a brinell number of 150 to 200 and yet possesses a peculiar toughness that withstands the action of the best tool steel. It possesses the elasticity and ductility of soft steel and at the same time possesses the extremely high tensile strength of 100,000 pounds per square inch.

The following are the physical properties of properly heat treated cast manganese steel:

Tensile strength	80,000 to 140,000 lbs. per sq. in.
Elastic limit	30,000 to 55,000 lbs. per sq. in.
Elongation	25% to 35%
Reduction of area	20% to 35%
Brinell hardness	170 to 200
Scleroscope hardness	40 to 50

Because of a peculiar slipping along its planes of cleavage when under heavy stress manganese steel does not have a definite yield point and this figure cannot be obtained by the drop of the beam. For the same reason the elastic limit is hard to obtain. A ½-inch square cast bar after heat treatment should bend 180 degrees around a pin of its own diameter.

The shearing strength is high—much higher than one would expect from the elastic limit. This is caused by the hardening during cold deformation mentioned later.

Manganese steel as cast has an austenitic structure with carbides segregated along the grain boundaries of the austenite grains and scattered throughout the grain itself, as shown in Fig. 2.

When properly annealed and quenched these carbides are dissolved into the austenite at the high temperature and, due to the obstructive action of the high manganese content, are retained in solution by the drastic quench in water, as shown in Fig. 3. If improperly heated or quenched, portions of these carbides may either remain undissolved because of insufficient annealing or come out of solution again because of slow cooling during the quench, as shown in Fig. 4.

At times the stresses set up in the metal while cooling may develop slip planes in the austenite grains. In Fig. 5 these are shown as hair lines running along the cleavage planes of the separate austenite grains.

When manganese steel is given a drawback after water quenching it loses its toughness and changes to a hard brittle martensitic or cementitic structure. When it is given a sufficient drawback to reach a brinell number of 450 it will possess a specific magnetism approximately 40 per cent of that of Swedish iron rated at 100 per cent. The lancelike structure seen when viewed under the microscope, and the high specific magnetism identify the structure definitely as martensitic, at least to a considerable degree.

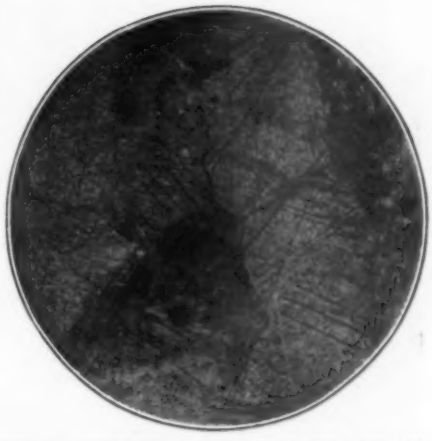


FIG. 5—STRESSES SET UP IN THE METAL DURING COOLING CAUSE SLIP PLANES IN THE AUSTENITE GRAINS WHICH ARE SHOWN AS HAIR LINES ALONG CLEAVAGE PLANES OF THE SEPARATE GRAINS

When subjected to severe stresses such as compression, tension, or repeated blows, manganese steel tends to slip along its planes of cleavage and develops a hard structure which in extreme cases reaches a brinell hardness of 500.

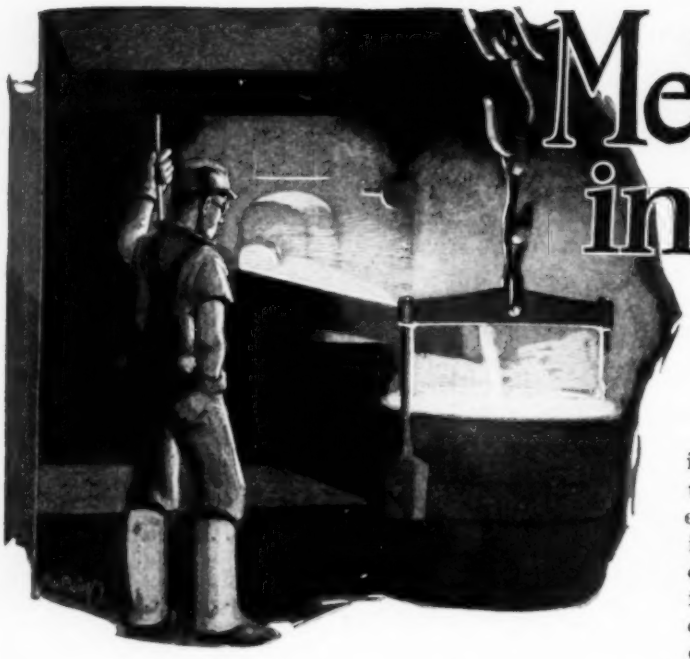
The superior wear resisting properties of manganese steel are due, to a considerable extent, to the hardening action that takes place when the casting surface is subjected to shock. As the surface is slowly worn away the newly exposed surface has been hardened by the previous shock and thus there is throughout the life of the wearing part a tough body of metal with an extremely wear resistant surface at all times exposed to the abrasive material. At times a casting subjected to extremely heavy shock and seemingly the worst possible type of service may wear even better, due to this extreme increase in hardness, than a casting receiving a purely abrasive wear.

Manganese steel castings stand in a class by themselves for use in many wear resisting and shock absorbing parts. A few of the specific uses are as follows:

Railroad work—Frogs, switches, crossings, guard rails, etc.

Crusher parts—Liner plates for ball and rod mills, mantles for gyratory crushers, hammers for hammer mills, jaw plates and roll shells.

Other miscellaneous parts—Dippers and dipper teeth, tractor shoes, chain, sand suckers and pumps, conveyors, chutes, gears, sheaves, etc.



Melting Iron in the Cupola

By J.E.Hurst

Part XIV

PATENT literature of the world has been enriched by at least a dozen patents annually for a number of years, concerning either minor modifications or radical alterations with the object of improving the working, efficiency and economy of the cupola. Attempt to describe even a few of the various proposed modifications is quite impossible.

Attempts to improve cupolas fall into two main groups (1) Improvement in detail design to meet special construction or production conditions. (2) Improvement of overall efficiency. No distinct line of demarcation exists between these two groups. Almost invariably any alteration whatsoever is claimed to increase the efficiency. Claims for 25 to 30 per cent fuel economy combined with low sulphur content in the iron are circulated freely.

Detachable wells and slag separating devices dealt with in previous chapters fall in the first group. A recent British patent No. 175207 by C. E. Taylor covers a tangential tuyere arrangement and a specially shaped wind belt. Construction, illustrated in Fig. 96, shows the usual channel shaped wind belt, eccentrically disposed in relation to the cupola shell in such a manner as to gradually decrease the cross sectional area from the air inlet. The object of this construction is to obtain a uniform pressure at all points in the wind belt. Gradual constriction of the wind belt area presumably is proportional to the pressure losses due to friction and other causes.

Special cupola construction, illustrated in Fig. 95, manufactured by the Constructional Engineering Co. Ltd., is due to Cameron. It bears considerable resemblance to the original Ireland cupola. The wind belt is embodied within the lines of the shell. A single row of tuyere openings forms practically a continuous tuyere on the inside. Efficient melting and fuel economy are claimed for this construction.

Another special construction due to Levoz is described in a recent British patent No. 187577. The Ronceray cupola is remarkable for its extreme simplicity. A simple cylindrical shaft entirely devoid of the usual column supports is suspended from the charging floor framework. Fig. 37, reproduced in the Nov. 15, 1928 issue of THE FOUNDRY, shows the Ronceray syphon brick and drop bottom. Dispensing with the columns is claimed

Use Waste Heat

VARIOUS forms of construction have been tried in the past and experiments still are going forward with a view of increasing the efficiency of the cupola. Slag separating devices have extended the operating period and have delivered cleaner metal. Rectangular shaped cupolas have been tried, also tangential tuyeres. Attempts to improve the quality of the metal have been made by the addition of ferroalloys in the cupola and ladle and by reducing the carbon. Utilization of waste cupola heat has attracted the attention of several investigators and several interesting installations of equipment for this purpose have been tried out in European and American foundries.

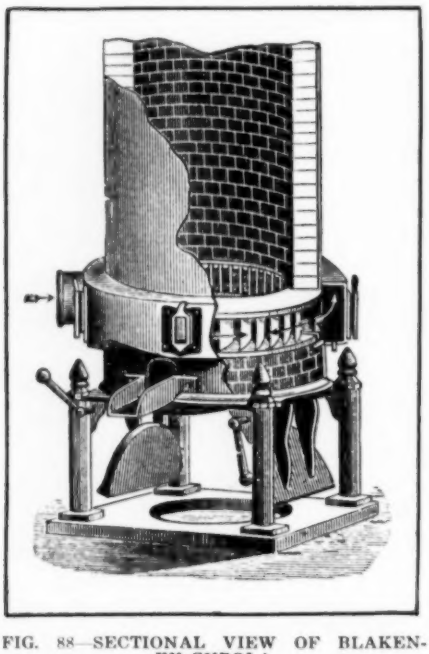


FIG. 88—SECTIONAL VIEW OF BLAKENEY CUPOLA

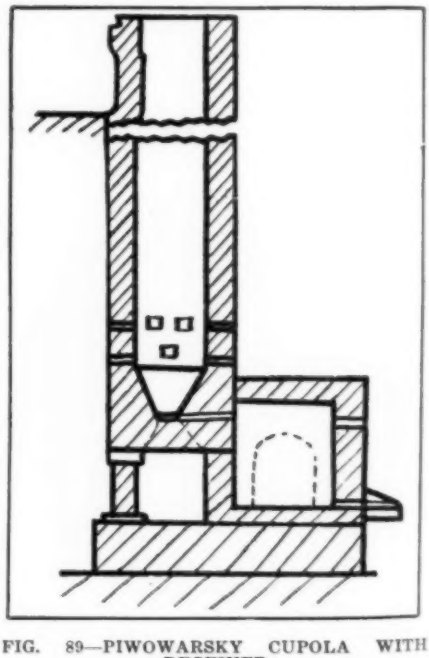
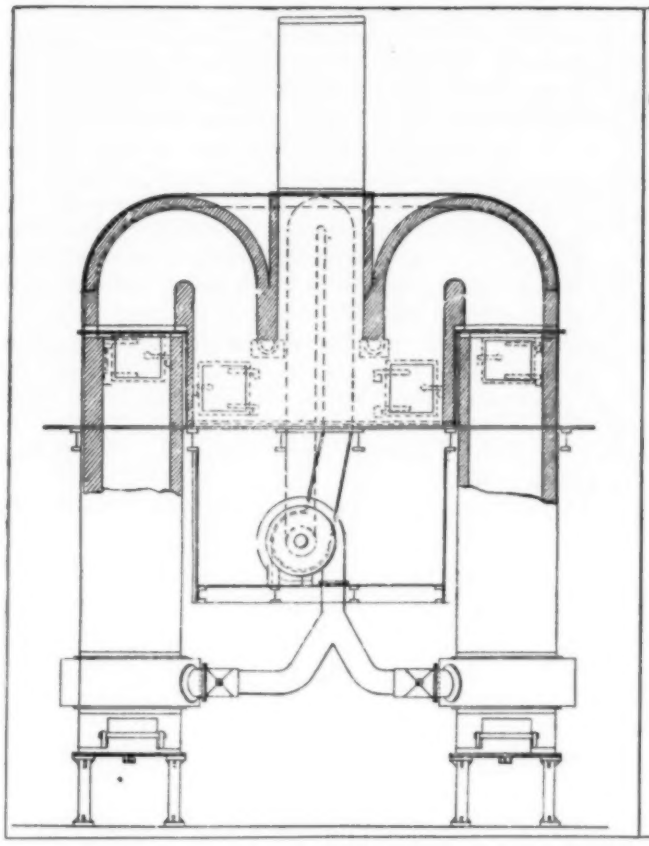


FIG. 89—PIWOWARSKY CUPOLA WITH RECEIVER



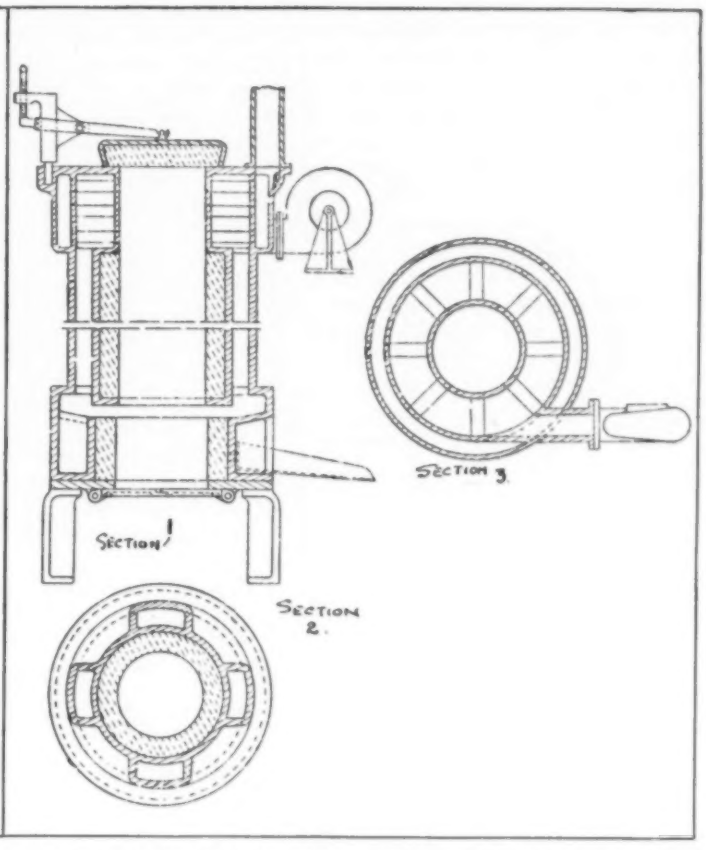
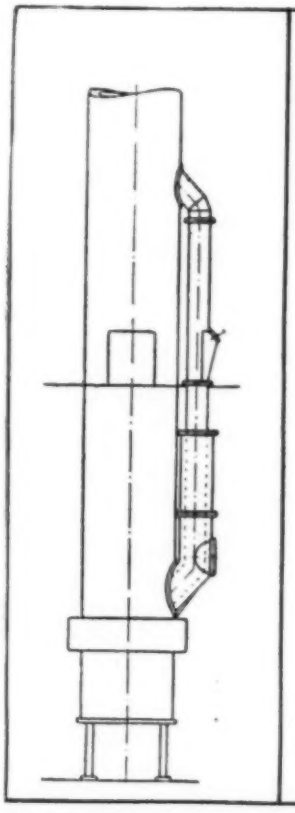


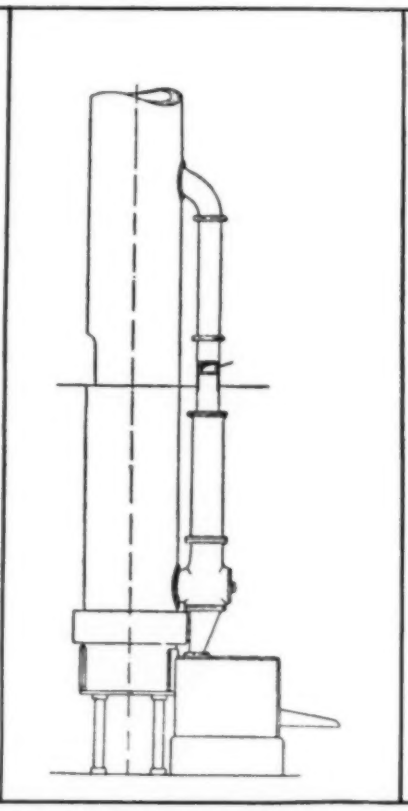
FIG. 90—HOT BLAST ARRANGEMENT APPLIED TO TWO CUPOLAS. FIG. 91—TYPE OF HOT BLAST CUPOLA DEVELOPED BY SMITH

to facilitate all work in the vicinity including cleaning up after the heat.

Kirk describes a reversion to the rectangular form in the Peevie cupola. Small sizes were square in cross section and the larger sizes were rectangular. Increase in capacity was obtained by extending the long side of the rectangle. Kirk states this construction was peculiarly liable to bridging.

The Blakeney cupola equipped with





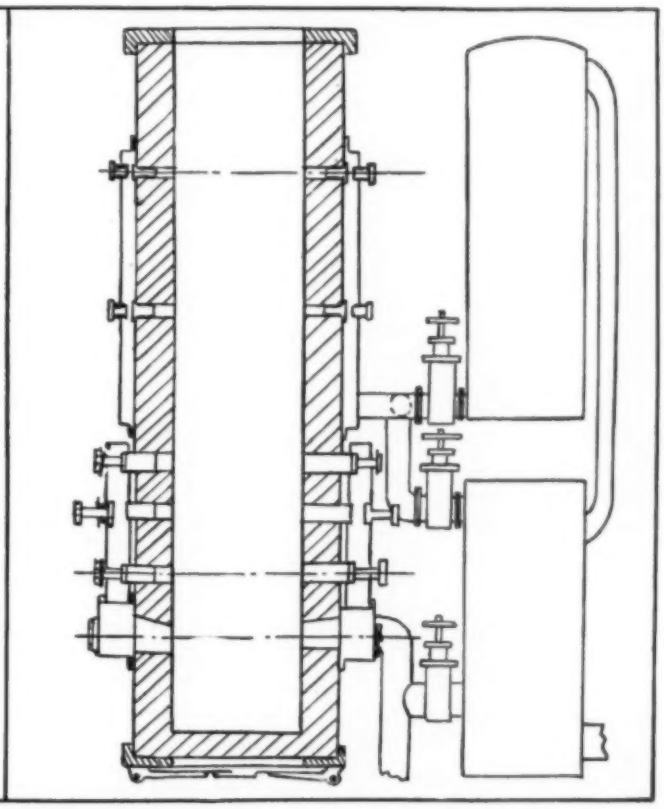


FIG. 92—AUXILIARY MELTING APPARATUS WITHOUT RECEIVER. FIG. 93—AUXILIARY MELTING APPARATUS FOR RECEIVER TYPE CUPOLA. FIG. 94—ARRANGEMENT OF AUXILIARY TUYERES DESCRIBED IN GREINER AND ERF'S ORIGINAL PATENT SPECIFICATIONS

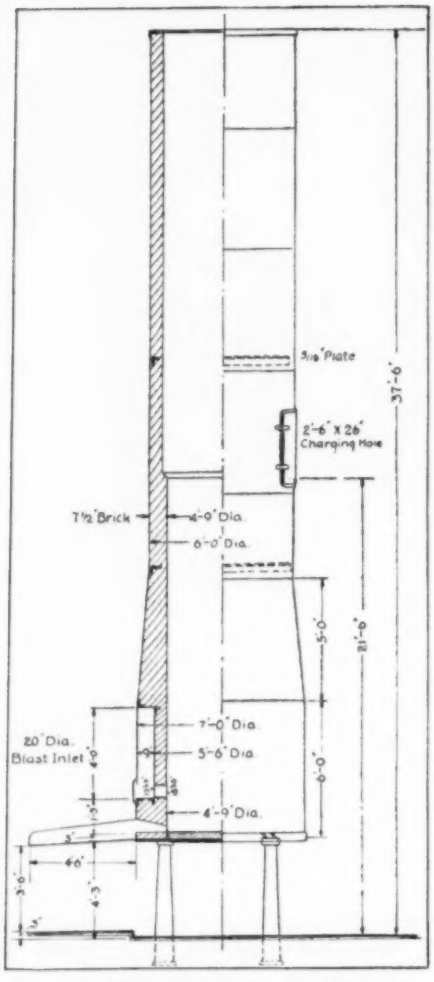


FIG. 95—RAPID MELTING CUPOLA PATENTED BY JOHN CAMERON

tangential tuyeres, described by Kirk and illustrated in Fig. 88, is stated to have given every satisfaction.

Special adaptation of the ordinary cupola to receive additions of ferrosilicon and ferromanganese to the molten metal lying in the hearth of the cupola or in a receiver is the feature of the so-called Corsalli process. Two forms of construction are illustrated in Figs. 92 and 93 showing the arrangements for use respectively with and without a receiver. Auxiliary melting apparatus takes the form of a pipe lined in the lower part with brick or other refractory material extending from the melting zone of the cupola to the extension of the cupola stack. A charging opening at the charging platform level is closed with a hinged door, a flap valve. Ferroalloys are charged through this opening in fairly large pieces preferably the size of a man's fist. A small admixture of charcoal is necessary, especially where the material is added in small pieces. Otherwise the material will cover the small slit connection to the cupola and thus prevent the flame from entering the tube. Where the apparatus is used with a receiver, according to recommendation, the melted alloys flow direct through a slit connection into the receiver. It is claimed that a temperature as high as 1600 degrees Cent. is developed in the pipe connection.

A special type cupola has been designed and patented by Piwowarsky for the express purpose of producing low carbon cast iron. The peculiar feature of this cupola diagrammatically represented in Fig. 89 is that the well is conical. It is claimed that the absorption of carbon is diminished in this cupola and further precautions can be taken by filling the well with graphite instead of coke.

Amount of heat lost through sensible and latent heat in the gases issuing from the throat of the cupola,

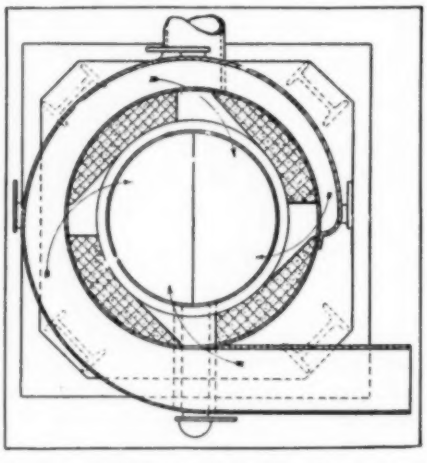


FIG. 96—TUYERES ARE SET AT A TANGENT AND THE WIND BELT GRADUALLY DECREASES IN SIZE

naturally has prompted various proposals to divert this to actual melting operation. These various proposals fall into three classes. Those in which attempts are made to utilize the waste heat to provide hot blast. Those in which attempts are made, by the introduction of a secondary air supply, to burn the carbon monoxide formed in the cupola. Various suggestions for the utilization of waste heat for such purposes as heating and drying ladles, molds and firing waste heat boilers.

Use of waste heat for auxiliary purposes preceded the attempts at economy in other directions. Attempts at thermal economy rapidly were followed by attempts to utilize the waste heat as hot blast. Presumably the signal economies effected by hot blast in blast furnaces did much to inspire similar attempts with cupolas.

Various arrangements have been referred to in an earlier chapter. These included coils suspended in the cupola stack, economizer arrangement of pipes in separate brick chambers through which the hot gases were led, pipes embedded in the brick lining, hollow shells. In all cases the air blast was conducted through pipes preheated by the outgoing gases. A portion of the heat in this manner was imparted to the blast and this hot blast in turn was expected to create higher temperature conditions in the cupola and consequently promote more rapid and economical melting.

One of the most modern attempts to revive the hot blast cupola recently has attracted some attention under the title of the Schurmann cupola. Of several other arrangements proposed,

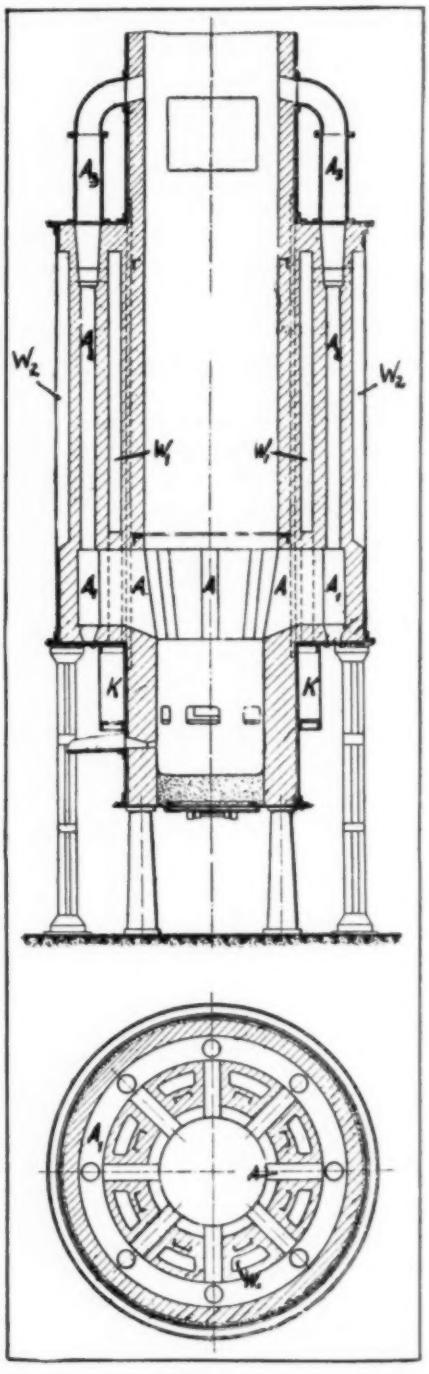


FIG. 97—HOT BLAST CUPOLA DESIGNED BY HAMMELRATH

two are illustrated in Figs. 90 and 91. The design indicated in Fig. 90 is due to Roper (British patent No. 203757) in Fig. 91 to Smith (British patent No. 239649). In both the method of operation clearly is indicated in the illustrations.

The Schurmann cupola has been described as a side blast cupola with reversing regenerators. Essentially, however, it may be regarded as a hot blast cupola, invented by the owner of a foundry at Coswig, Germany, who was granted the original German patent No. 266303. A typical diagram of the Schurmann arrangement, Fig. 98, shows two regenerator chambers erected alongside the cupola and connected to two sets of tuyere passages. The regenerator chambers are filled with checker brickwork as in open-hearth furnace practice. Upper extremities of the regenerator are connected to a four-way reversing butterfly valve by which flow of ingoing air and exit gases can be reversed through either of the two regenerators. The blast enters the reversing valve, passes through the regenerator and enters the cupola. The waste gases pass by the way of the tuyere openings into the regenerator and communicate a portion of their sensible heat to the checker work, passing finally to atmosphere by way of the reversing valve and throttle valve into the chimney. In operation, the direction of the ingoing air is reversed every 10 minutes and as a result of passing through the regenerators heated by the passage of the outgoing gases during the period prior to the reversal, the air blast is injected hot into the cupola.

Cold air from the blowers is stated to be preheated to a temperature of 800 degrees Cent. in the regenerator and after passing through the cupola and the second regenerator, the gases are discharged to the atmosphere at

(*Concluded on Page* 258)

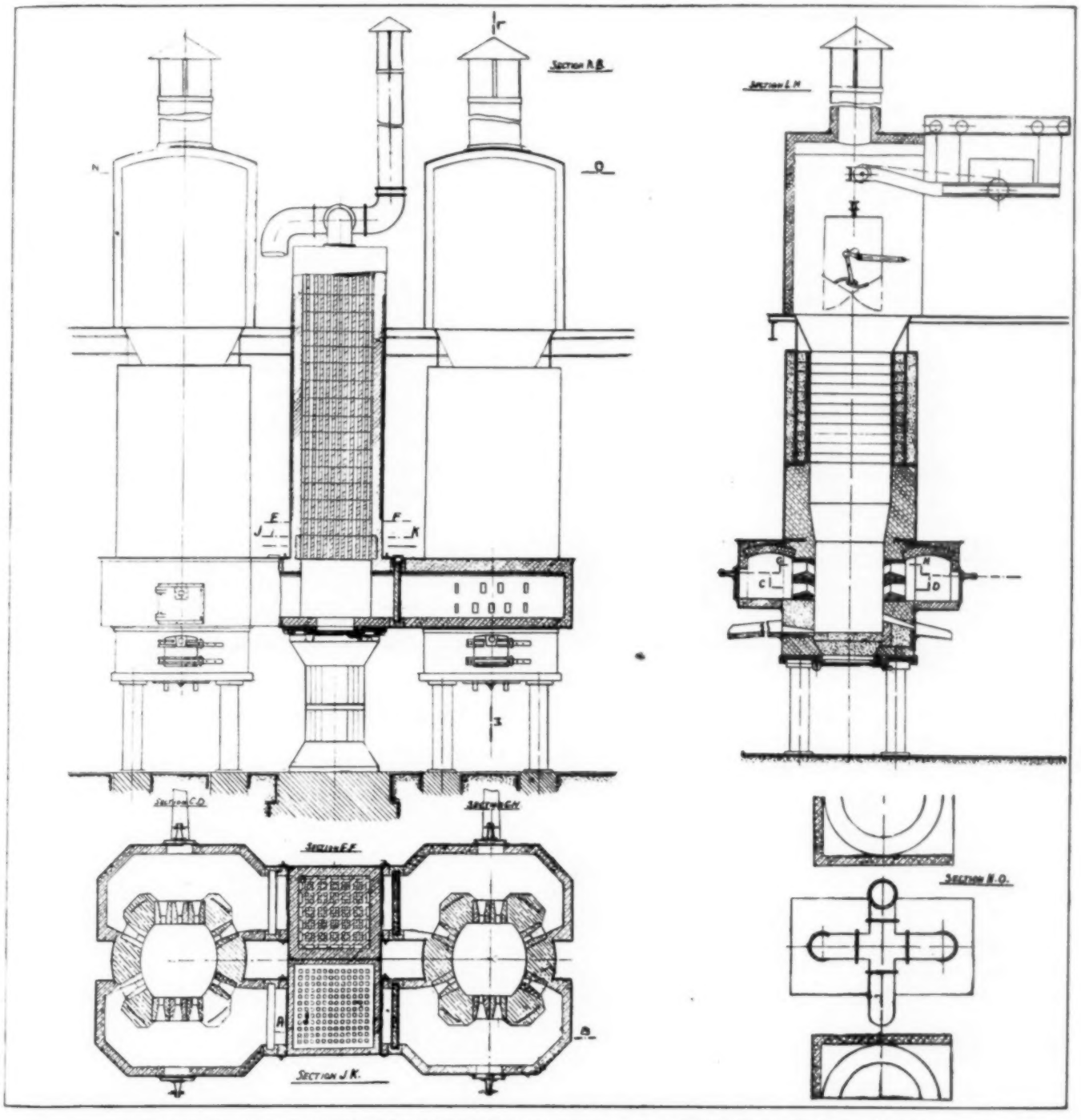


FIG. 98—GENERAL ARRANGEMENT AND SECTIONAL VIEWS OF SCHURMANN HOTBLAST CUPOLA

Heat Treating Improves

Physical Properties of

Carbon and Alloy Steel Castings

By J. Edward Donnellan

A LARGE tonnage of carbon steel castings is shipped without receiving any form of heat treatment. Such castings fulfill all requirements for certain classes of service and heat treatment may not be necessary. However, potential properties are developed by subjecting them to some form of heat treatment that increases their life in service.

Untreated castings have a higher tensile strength than annealed castings but the ductility and impact values are low. The cast structure is broken up by annealing or normalizing and a much better distribution of the constituents is obtained throughout the castings. Castings will resist shocks encountered in service better in the treated condition.

Although both alloy and plain carbon steel castings are improved greatly by heat treatment, including quenching and tempering, the latter should not be specified by the customer unless he knows definitely what is wanted, and knows that the regular anneal or normalizing treatment will not be sufficient to give the physical properties for service requirements. Castings should be allowed to cool in the molds after pouring to a temperature below the critical range. Brittleness increases as the temperature drops, especially with alloy castings. Therefore, it is advisable to shake out and clean alloy castings before they become black. If adhering sand is not removed, it is more difficult to secure a uniform penetration of heat and more time is required for the operation. Risers and gates should be removed before heat treating because they are difficult to heat and increase the heat treating cost.

Because of the brittleness of alloy castings, it is good practice to remove risers while the castings are warm by flame cutting and not by breaking, which often starts minute cracks.

It may not be possible always to prepare castings for heat treatment before they become cold, but if it is, advantage may be taken of the remaining heat in the castings and the introduction of cooling strains is eliminated. This practice is quite important when dealing with alloy castings.

The selection of the proper heat treatment depends upon the composition, design, physical requirements, and the size of the castings. The chemical compositions for low carbon and alloy castings which generally are used for ordinary construction purposes are given in Table I. To take advantage of the properties that steel castings are capable of developing, they should be subjected either to an annealing, normalizing or quenching and tempering treatment. One or more of these treatments or some modification, according to requirements and conditions, is essential in developing the physical properties. The terms normalizing and annealing are confused in many shops. Although normalizing is a form of annealing, the

Gives Data in Report

SUBCOMMITTEE of the recommended practice committee of the American Society for Steel Treating on the heat treatment of steel castings has prepared tentative recommended practices covering the heat treatments of carbon and alloy steel castings. This article is abstracted from the report covering the practices and is supplemented with micrographs and data. It was presented at the Western Metal congress held in Los Angeles, Jan. 14-17, under the auspices of the American Society for Steel Treating. The author of the report is the secretary of the technical committees of the society and editor of its handbook. A. W. Lorenz, Bucyrus-Erie Co., Milwaukee, co-operated in preparing the report by making the test coupons, heat treating the steels and making the physical tests.

Table I

Chemical Composition of Low Carbon and Alloy Steel Castings

Steel No.	Type of Steel	Carbon Per cent	Manganese Per cent	Silicon Per cent	Chromium Per cent	Nickel Per cent	Vanadium Per cent	Molybdenum Per cent
	Low Carbon†	0.15-0.60	0.50-0.90	0.20-0.60				
1	C-V	0.25-0.35	0.60-0.90	0.20-0.50*			0.15-0.20	
2	C-V	0.35-0.45	0.60-0.90	0.20-0.50*			0.15-0.20	
3	C-V	0.45-0.55	0.60-0.90	0.20-0.50*			0.15-0.20	
4	C-Cr	0.25-0.35	0.60-0.90	0.20-0.60	0.80-1.10			
5	C-Cr	0.35-0.45	0.60-0.90	0.20-0.60	0.80-1.10			
6	C-Cr	0.45-0.55	0.60-0.90	0.20-0.60	0.80-1.10			
7	Cr-V	0.25-0.35	0.60-0.90	0.20-0.60	0.80-1.10		0.15-0.20	
8	Cr-V	0.35-0.45	0.60-0.90	0.20-0.60	0.80-1.10		0.15-0.20	
9	Cr-V	0.45-0.55	0.60-0.90	0.20-0.60	0.80-1.10		0.15-0.20	
10	Cr-Ni	0.25-0.35	0.60-0.90	0.20-0.60	0.50-0.90	1.25-1.75		
11	Cr-Ni	0.35-0.45	0.60-0.90	0.20-0.60	0.50-0.90	1.25-1.75		
12	Cr-Ni	0.45-0.55	0.60-0.90	0.20-0.60	0.50-0.90	1.25-1.75		
13	Cr-Mo.	0.25-0.35	0.60-0.90	0.20-0.60	0.70-1.00			0.25-0.35
14	Cr-Mo	0.35-0.45	0.60-0.90	0.20-0.60	0.70-1.00			0.25-0.35
15	Cr-Mo	0.45-0.55	0.60-0.90	0.20-0.60	0.70-1.00			0.25-0.35
16	Mn	0.25-0.35	1.00-1.50	0.20-0.50				
17	Mn	0.25-0.35	1.50-1.75	0.20-0.50				
18	Mn	0.35-0.45	1.00-1.50	0.20-0.50				
19	Mn	0.35-0.45	1.50-1.75	0.20-0.50				

†The carbon content is sub-divided in the tables where heat treatments are prescribed.
*0.20 to 0.30 per cent silicon preferred.

operations and results obtained are different.

The joint committee on the definition of heat treatment terms, composed of representatives from the American Society for Steel Treating, American Society for Testing Materials and the Society of Automotive Engineers is assisting in clarifying this confusion and misuse of terms. The tentative definitions proposed by the committee for these operations are are follows: Annealing is a heating and cooling operation of a material in the solid state. This process usually implies a relatively slow cooling. Annealing is a comprehensive term.

Table III

Heat Treatments for Alloy Castings

Steel Nos. as listed in Table I	Temperature degrees Fahr.	Cool in	Treatment
1, 2, 3, 16, 17, 18, 19	1600-1700	Air	Normalizing
4 to 15	1600-1800	Air	Normalizing
1, 2, 3, 16, 17, 18, 19	1500-1600	Furnace	Annealing
4 to 15	1550-1650	Furnace	Annealing

Table II

Heat Treatments for Carbon Castings

Carbon range	Temperature degrees Fahr.	For normalizing cool in	For annealing cool in
0.15-0.40	1600-1700	Still Air	Furnace or other medium for cooling slowly*
0.40-0.60	1550-1600	Still Air	Furnace or other medium for cooling slowly*

*The castings are cooled slowly until the temperature has dropped to 800 degrees Fahr. or below.

The purpose of such a heat treatment may be: (*a*) to remove gases, (*b*) to remove stresses, (*c*) to induce softness, (*d*) to alter ductility, toughness, electrical, magnetic or other physical properties, or (*e*) to refine the crystalline structure of the metal.

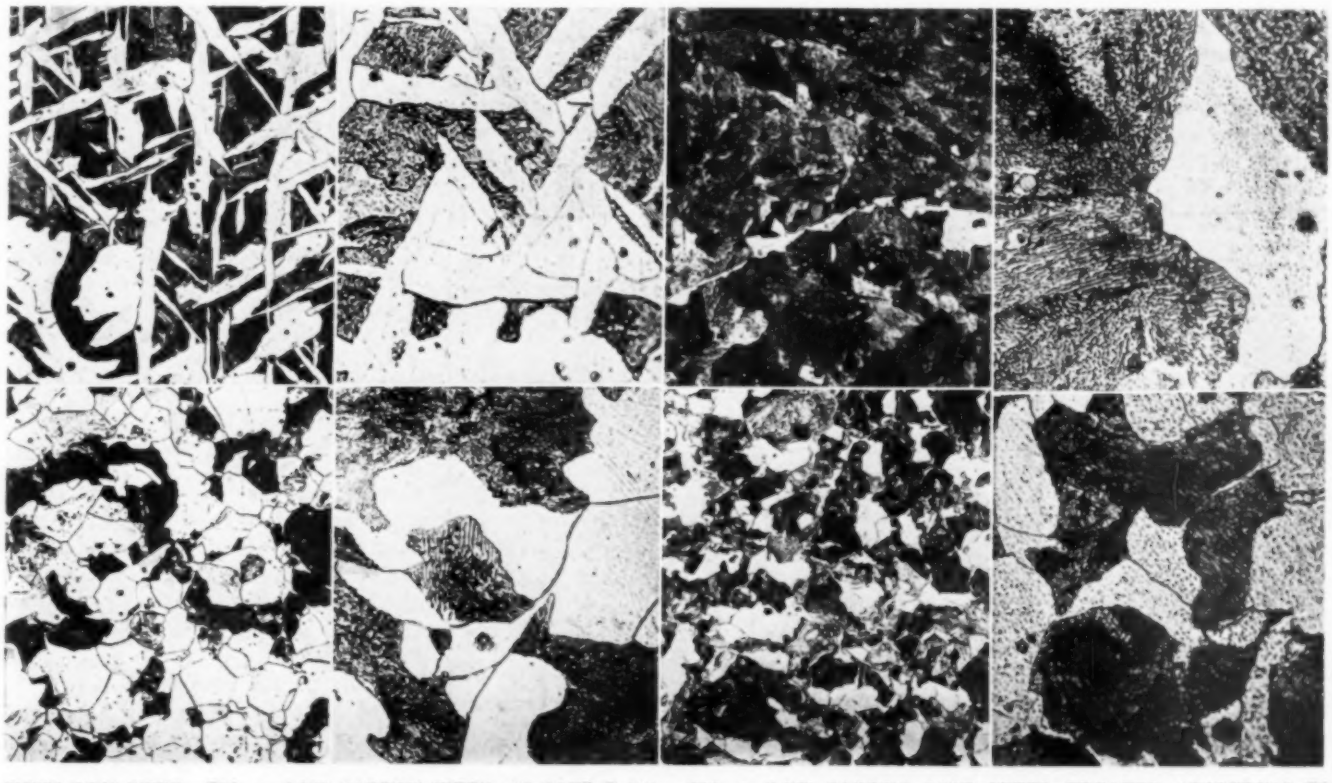
Certain specific heat treatments come under the term annealing. Full annealing is the heating of iron-base alloys above the critical temperature range for a proper period of time followed by slow cooling through that range. The annealing temperature is generally 100 degrees Fahr. above the upper limit of the critical range, and the time of holding usually is not less than one hour per inch of section of the heaviest object being treated. The objects being treated ordinarily are allowed to cool slowly in the furnace. However, they may be removed from the furnace and cooled in some medium which will prolong the time of cooling as compared to unrestricted cooling in air.

Normalizing is the heating of iron-base alloys above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.

The normalizing and annealing temperatures for carbon and alloy steel castings are given in Tables II and III respectively.

A double normalizing treatment sometimes is employed where quality is of utmost importance. The castings are first heated to a high temperature, ranging from 1600 to 2000 degrees Fahr. This high temperature breaks up the casting structure, diffuses the segregates and forms a homongenous structure. To refine the coarse structures resulting from the high temperature, the castings are reheated to a temperature between 1475 and 1600 degrees Fahr.

This treatment is beneficial in pro-



(FIRST ROW LEFT)—FIG. 1—LOW CARBON STEEL AS CAST X 100. FIG. 2—LOW CARBON CAST STEEL TREATED ACCORDING TO HEAT TREATMENT *LA* X 100. (SECOND ROW)— FIG. 3—SAME AS FIG. 1 X 500. FIG. 4—SAME AS FIG. 2 X 500. (THIRD ROW) —FIG. 5—NICKEL-CHROMIUM STEEL AS CAST X 100. FIG. 6—SAME STEEL AS FIG. 5 GIVEN HEAT TREATMENT *NA* X 100. (FOURTH ROW)—FIG. 7—SAME AS FIG. 5 X 500. FIG. 8 SAME AS FIG. 6 X 500

Table IV

Quenching and Tempering Carbon Steel Castings

Carbon Range	Quenching Temp. Deg.* F.	Time at Heat	Quenching Medium and Temp. Deg. F.	Tempering Tempering Temp. Deg. F.	Tempering Time at Heat
0.15-0.30	1600-1650	½ hr. for every inch of dia. or thickness	Water at 70	800-1350	At Least 3 hrs.
0.30-0.40	1550-1600	½ hr. for every inch of dia. or thickness	Water at 125	800-1350	At Least 3 hrs.
0.40-0.60	1500-1550	½ hr. for every inch of dia. or thickness	Water at 125 or Oil	800-1350	At Least 3 hrs.

*These temperatures are based on the assumption that the castings were first annealed.

ducing homogenous steel, but has disadvances in that the high temperature is severe on the furnace linings, produces scaling, and with certain designs, warping.

With castings of large cross sections this high temperature normalizing treatment is necessary to secure complete refinement of structure and uniform physical properties of the metal throughout the section.

W. J. Merten has covered successfully this high normalizing treatment in a paper published, January, 1928, in the *Transactions*, American Society for Steel Treating. Mr. Merten recommends the following treatment for normalizing large castings of over 50,000 pounds.

"Heat the castings slowly and uniformly to 2012 degrees Fahr. (1100 degrees Cent.) under atmospheric conditions that will cause minimum scaling. The minimum time rate to reach that temperature should be approximately 1½ hours per inch of minimum dimensions of the heaviest section. Hold at this temperature for at least 2 hours per inch of width of cross section. Cool in the furnace with the door open to 1600 degrees Fahr., and then in air until black 800 degrees Fahr.) Reheat to 1600 degrees Fahr. at a rate of 1 hour for every inch of width of cross section. Hold at 1600 degrees Fahr. one hour for every inch of width of cross section. Cool in air to black heat. Reheat to 1275 degrees Fahr. and cool in furnace to 600 degrees Fahr., then in air.

After normalizing carbon castings at the temperatures given in Table II, they may be tempered at some temperature below the critical temperature range, depending upon requirements, but 1200 degrees Fahr. usually is the temperature suitable for most purposes. This tempering gives better ductility and relieves the cooling strains. Alloy castings in most cases should be tempered after normalizing to relieve the brittleness and strain caused from the air quench and also to increase the ductility and impact values.

By full annealing castings, that is, heating well above the critical range and cooling slowly, a fairly uniform but not fine grained structure is secured. The structure is much finer by faster cooling, such as air cooling, and the physical properties are higher. Full annealing is not necessary for most classes of castings unless on heavy sections and for alloy castings for machining.

The design and size of the casting are the governing factors in deciding whether or not a casting should be quenched. Intricately designed castings should not be given that treatment as cracks are likely to develop. These often appear internally and are not detected until after the castings are in service. Where quenching is required the design should be such that the operation is practical and will not produce cracks.

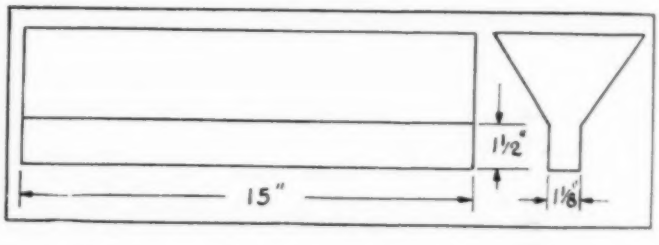


FIG. 9—DIMENSIONS OF TEST BARS USED IN THE TESTS

Water or oil quenched castings develop the maximum available properties of the steel. Alloy castings should receive some form of quench, either water, oil or air to derive the benefits of the alloys. With certain designs and with castings containing defects there is danger of cracking from the liquid quenching. Where such dangers are apparent, but a quench is necessary to develop required properties, some form of air quenching may be of help in accomplishing the desired end. Such castings may be cooled in air as in normalizing. The furnace doors may be so manipulated that the proper rate of cooling is obtained ,or the cooling may be accelerated by using an air blast, provided the design of the casting will permit. Such accelerated air cooling also may be resorted to with large castings requiring a quenching treat-

Table V

Quenching and Tempering Alloy Castings

Steel Nos. as listed in Table II	Type of Steel	Quenching Temperatures Degrees Fahr.	Quenching Medium‡	Maximum Tempering Temperatures Degrees Fahr.	Cool in
1	C-V	1550-1600	Water or Oil	1300	Air or Furn.
2	C-V	1500-1550	Water or Oil	1300	Air or Furn.
3	C-V	1475-1500	Water or Oil	1300	Furnace
4	C-Cr	1575-1650	Water or Oil	1275	Air or Furn.
5	C-Cr	1525-1575	Water or Oil	1275	Air or Furn.
6	C-Cr	1500-1525	Water or Oil	1275	Furnace
7	Cr-V	1575-1650	Water or Oil	1275	Air or Furn.
8	Cr-V	1525-1575	Water or Oil	1275	Air or Furn.
9	Cr-V	1500-1525	Water or Oil	1275	Furnace
10	Cr-Ni	1515-1550	Wtaer or Oil	1250	Air or Furn.*
11	Cr-Ni	1490-1515	Water or Oil	1250	Air or Furn.*
12	Cr-Ni	1475-1490	Water or Oil	1250	Furnace*
13	Cr-Mo	1575-1650	Water	1300	Air or Furn.†
14	Cr-Mo	1525-1575	Oil	1300	Air or Furn.†
15	Cr-Mo	1500-1525	Oil	1300	Furnace†
16	Mn	1600-1650	Water	1250	Air or Furn.
17	Mn	1600-1650	Water	1250	Air or Furn.
18	Mn	1550-1600	Water	1250	Air or Furn.
19	Mn	1550-1600	Water	1250	Air or Furn.

‡Air quenching is often made use of in the hardening of alloy steel castings of intricate design which would be likely to crack in the more drastic water or oil quench.

*The shock resistance is sometimes improved by oil quenching from the tempering temperature.

†A long soak is required at the tempering temperature.

ment to develop their properties.

After quenching, the castings should be tempered to relieve the quenching strains and to develop the properties required. As the temperature of the temper is increased the hardness is decreased, but the reduction of area, elongation and impact values are increased.

The tempering and quenching temperatures for castings as recommended by the steel castings committee of the American Society for Steel Treating are given in Tables IV and V.

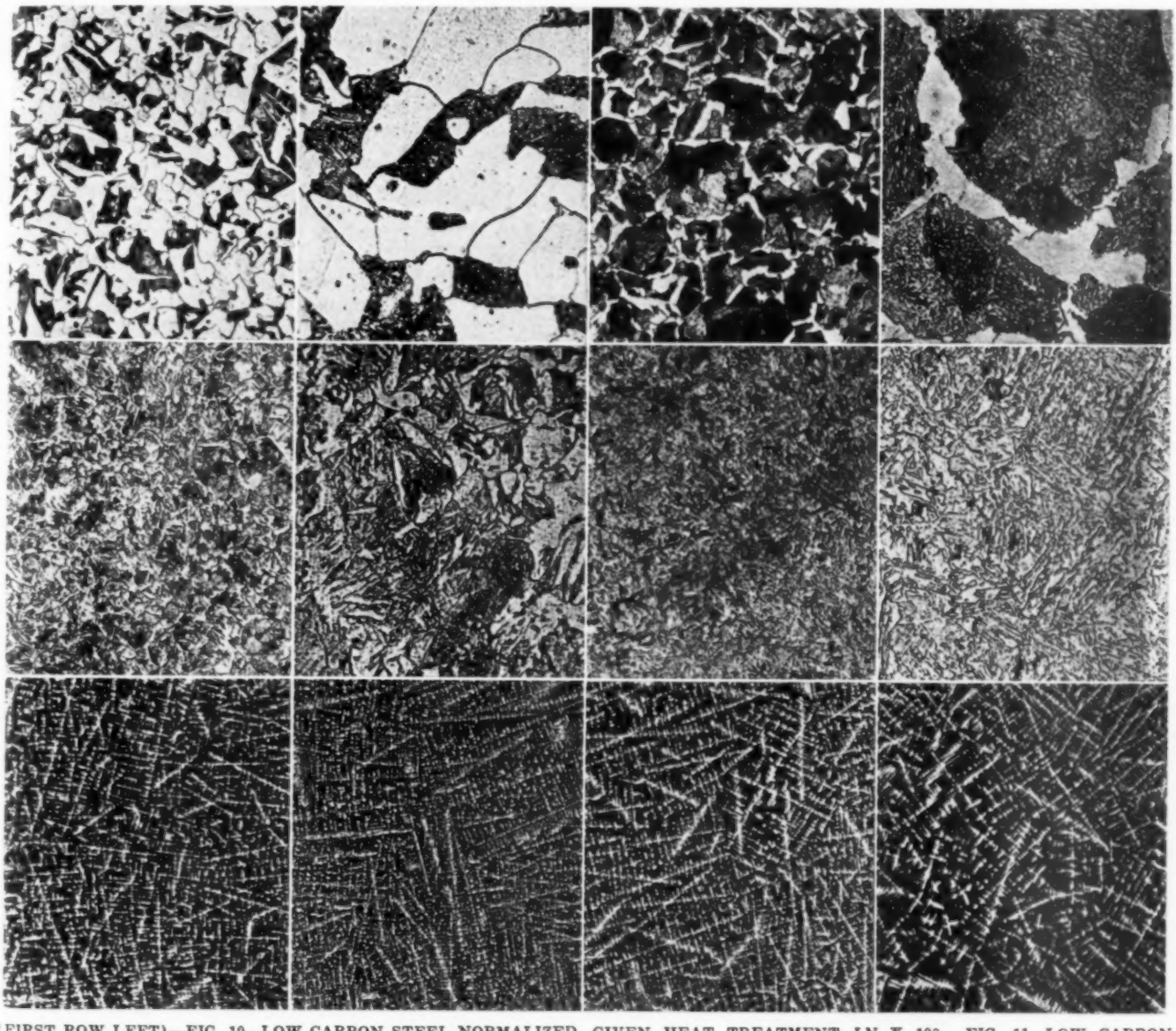
Pyrometric control is essential to attain good results from any heat treating operation, although there are annealing and normalizing treatments that are fairly well conducted without pyrometers. However, the eye is not the most reliable means of temperature control for duplicating results from day to day, although the eye must be relied upon in maintaining uniform temperature. By placing thermocouples in different sections of the charge and matching the colors in these sections with the rest of the charge, a uniform temperature can be maintained throughout the furnace.

Test samples may be distributed throughout the furnace for fracture inspection after heat treatment to augment that method of control. Care must be exercised when inspecting such fractures, as the test fracture is not always the index to the structure of the castings. The size of specimen, position in furnace, size of charge, and methods of cooling are governing factors.

Castings and patterns usually are designed to avoid warping during the solidification period. However, it often is necessary to make alterations to avoid that defect. It also occurs from stresses and bending in the heat treatment operations. When warping does occur, some means of straightening must be used, either hot or cold. With castings of good ductility and of not too heavy cross section, straightening may be done cold, preferably with a suitable press which provides a slow, steady pressure.

The method of straightening by dropping a weight or pounding the castings is exceedingly poor practice as cracks are likely to be formed either externally or internally.

In hot straightening, as well as in welding, the beneficial effects of heat treatment may be entirely lost. If the



(FIRST ROW LEFT)—FIG. 10—LOW CARBON STEEL NORMALIZED GIVEN HEAT TREATMENT *LN* X 100. FIG. 11—LOW CARBON STEEL QUENCHED AND TEMPERED. TREATMENT *LH* X 100. FIG. 12—NICKEL-CHROMIUM STEEL AS CAST ETCHED IN LECHATELIER SOLUTION X 5. (SECOND ROW)—FIG. 13—SAME AS FIG. 10 X 500. FIG. 14—SAME AS FIG 11 X 500. FIG. 15—NICKEL-CHROMIUM STEEL ANNEALED ETCHED IN LECHATELIER SOLUTION X 5. TREATMENT *NA*. (THIRD ROW)—FIG. 16—NICKEL-CHROMIUM CAST STEEL ANNEALED BY HEAT TREATMENT *NN* X 100. FIG. 17—NICKEL-CHROMIUM CAST STEEL QUENCHED AND TEMPERED BY TREATMENT *NH* X 100. FIG. 18—NICKEL-CHROMIUM CAST STEEL NORMALIZED BY TREATMENT *NN* AND ETCHED IN LECHATELIER SOLUTION X 5. (FOURTH ROW)—FIG. 19—SAME AS FIG. 16 X 500. FIG. 20—SAME AS FIG. 17 X 500. FIG. 21—NICKEL-CHROMIUM CAST STEEL HARDENED AND TEMPERED ETCHED IN LECHATELIER SOLUTION X 5. TREATMENT *NH*

casting is heated locally then straightened, and allowed to cool in the air, stresses are introduced and if the temperature is sufficiently high the structure obtained in the heat treatment operation is destroyed. In such practice, the casting should be retreated. Better results are obtained if the entire casting is heated to a temperature just sufficient for the straightening, but below the temperature of the last heat treatment performed. After straightening, the castings should be cooled slowly to eliminate the stresses.

The type test bar or coupon used for determining the quality of the metal or the heat treatment, depends upon the conditions comprising the problem, such as design, size and service. The design of the test coupon and its position on the casting should be such that the coupon is sound. To represent the metal in the casting, the coupon should approximate the maximum cross-section of the casting. The charge of castings should be arranged in the furnace and the heating conducted so that the castings and coupons receive the same treatment.

To reveal the difference in structure and the effect of heat treatment upon steel castings, two basic open-hearth steels were selected; one a plain steel whose analysis was carbon, 0.24, manganese, 0.92, silicon, 0.38, sulphur, 0.031, phosphorous, 0.013, and the other a nickel-chromium steel whose analysis was carbon, 0.30, manganese, 0.82, silicon, 0.37, sulphur, 0.028, phosphorus, 0.009, nickel, 1.73, chromium, 0.63.

The test coupons were of the form and dimensions as shown in Fig. 9. The bottom section was flame-cut from the feeder before performing any of the heat treating operations. The test section then was cut into 3 pieces each about 5 inches long and one small sample provided for microscopic examination of the steel in the *as cast* condition or before treatment.

The test specimens were subjected to an annealing, normalizing and quenching treatment. The symbols designating the processes to which the specimen were subjected follow:

L C—Low carbon steel as cast

L A—Low carbon steel annealed

L N—Low carbon steel normalized and tempered

L H—Low carbon steel water quenched and tempered

N C—Alloy steel as cast

N A—Alloy steel annealed

N N—Alloy steel normalized and tempered

N H—Alloy steel water quenched and tempered.

The *L C* and *N C* specimens were given no heat treatments; *L A* and *N A* specimens were annealed at 1650 degrees Fahr. with a 20-ton foundry charge in car-type furnace and tempered at 1200 degrees Fahr.

The *L H* specimen first was normalized at 1650 degrees Fahr. as described previously, then heated to 1600 degrees Fahr. in a box-type electric furnace with normal charge of 1500 pounds of castings, which had the same cross-section as the test bars. The full charge was plunged by a special quenching machine into water maintained at 135 degrees Fahr. for a period of 40 seconds and tempered at 1200 degrees Fahr.

The *N H* specimen was given the same treatment as *L H*, except the quenching temperature was 1500 instead of 1600 degrees Fahr.

The physical properties shown in Table VI were obtained after the specimens were heat treated.

Figs. 1 and 3 show the Widmanstatten or cleavage structure for the carbon steel in the *as cast* condition. This structure is quite typical for this class of steel. Figs. 5 and 7 show the alloy steel in the *as cast* condition. It should be noted that there is apparently much less free ferrite and that the cleavage structure is not in evidence in Figs. 5 and 7. The cause for this difference in structure may be due to several factors.

By subjecting these steels to a full annealing (see heat treatments *L A* and *N A*), the cast structure is eliminated entirely as shown in Figs. 2 and 4 for the carbon steel and Figs. 6 and 8 for the alloy steel. There is a uniform distribution of ferrite and pearlite in both steels, with a somewhat better distribution of both constituents in the alloy steel.

When these steels are normalized and tempered (see heat treatments *L N* and *N N*), the cast structure practically is eliminated, as shown in Figs. 10, 13, 16 and 19. However, traces of the cleavage structure remain in the carbon steel. The ferrite areas in the alloy steel appear to be smaller than in the same steel annealed and the pearlite is well distributed.

By normalizing these steels to eliminate the cast structure and then quenching and tempering as described previously (see heat treatments *L H* and *N H*), a fine, well distributed structure of troostitic-sorbite is obtained as shown in Figs. 11, 14, 17 and 20. Figs. 12, 15, 18 and 21 all show a dendritic structure which has not been changed in any way by the various forms of heat treatment.

The quenched alloy steel exhibits a finer structure and the constituents are more evenly distributed than in the carbon steel.

The yield points and tensile strength for both steels have been increased greatly by quenching and tempering as shown in Table VI, and the ductility for both steels is still very satisfactory.

Throughout the series of micrographs the nickel-chromium steel shows the better structure for all heat treatments. This is natural because the alloys promote solution of the constituents and help to make the steel respond more readily to heat treatments.

It is interesting to compare the full annealed structure with the normalized structure and the physical properties obtained from each heat treatment as shown in Table VI. The two treatments give similar results with better ductility for both steels in the normalized condition. It appears that a normalizing and tempering treatment is sufficient, especially with the alloy steel.

By quenching the normalized steels in water and then tempering, some worth while properties are developed and the steels retain good ductility. The structures thus obtained show homogeneous steels and are comparable to forged steel of similar composition.

Table VI

Physical Properties of Steel Castings After Heat Treating

Symbol	Treatment	Yield Pt. lbs. per sq. in.	Tensile Str. lbs. per sq. in.	Elong. per cent in 2 inches	Red. of Area Per cent	Brinell Hard. Numbers
L A	Annealed	38,250	70,600	32.5	49.2	143
L N	Normalized and tempered	37,250	69,150	38.0	60.6	137
L H	Quenched and tempered	53,850	80,050	32.5	65.6	170
N A	Annealed	55,650	96,400	24.0	45.7	179
N N	Normalized and tempered	54,250	93,950	26.0	51.1	179
N H	Quenched and tempered	95,450	114,550	22.0	55.5	228

How and Why in Brass Founding

By Charles Vickers

Want To Melt Heavy Wire

We want information on ingot copper and copper wire. Is there any difference between products made of ingot copper and those made from scrap trolley wire or any other good scrap copper wire? We have been told that used copper wire has lost something and that a bronze bearing made of scrap copper wire is not as high grade as if made from virgin copper.

The answer depends on a number of things outside the bare comparison between wire and ingot copper. Trolley wire, or other good scrap copper wire, is good melting size. Thin copper wire is not good melting stock unless it has been solidly compressed to leave no interstices for the atmosphere to get in its oxidizing work when the copper is heated. Always, of course, such wire must be copper throughout.

Trolley wire can be melted in crucibles, also in electric brass melting furnaces and its bronze product will be a formidable adversary to beat by electrolytic ingot copper. The writer has done this little thing many thousands of times. Trolley wire sometimes contains a small modicum of tin, but no foundryman ever objects to free tin for making bronze. The electric current passing through it has done absolutely no harm; it has lost no mysterious "something." True it has collected a thin coating of oxide, but a little phosphor copper in the bottom of the pot will take care of that small amount. Heavy coil wire from electric machines is pure copper. It has to be. Its only drawback as with the trolley wire is a thin coating of oxide. Experience shows that with ordinary good melting methods this oxide does no harm. The copper ingot gets a number of coats of oxide too, as it sweats down under the applied heat. In melting trolley or other heavy wire do not allow it to stick up above the crucible top. Coke-fired furnaces melt this sort of copper very nicely as they are usually deep enough to set a deepener on top of the crucible. If the wire is cut into lengths a trifle shorter than the depth of crucible and deepener, it can be stood on end in the pot, which will then contain the entire copper charge at once. With a couple of blocks of hard wood stuck in with the wire, the furnace can be permitted to work its will, and the entire wire charge will come down clean and liquid with its charcoal on top. That copper will make good bronze, do not doubt it.

In an oil-fired short furnace with no room for a deepener, the wire will have to be cut into small pieces and the pot cannot be filled at one melt. Additions of cold metal have to be made and a thin flux of glass will be an important help. This copper wire will give better bronze than some brands of casting copper. These latter often contain metalloids that are harmful. In fact in making manganese bronze, a touchy alloy, no casting copper is safe if great strength is wanted. Arsenic, phosphorus and antimony are taboo in such alloys as manganese bronze or aluminum bronze. Against ordinary brands of casting copper, give me the wire every time when castings have to meet specifications for physical properties.

Electrolytic copper or casting copper ingot might present a slight advantage, outside the advantage of being convenient to handle, but it is only a slight advantage against heavy and carefully-melted wire, and is not worth any great amount of attention. This can be proved by making a bearing of each kind of copper, and breaking them for fracture comparison.

Desires Pattern Metal

We have a number of molding machine plate patterns to make and before we make our master patterns we would like you to give us a formula for a white metal mixture that will neither shrink nor expand and that can be soldered.

The following alloy is suggested: Tin, 58.65 per cent; zinc, 22.22 per cent; lead 12.63 per cent; antimony 6.50 per cent. Another alloy that is used frequently for patterns is tin, 50 per cent and zinc 50 per cent. These mixtures have the minimum amount of shrinkage and can be soldered when it is necessary.

Spots Spoil Castings

We are starting to make brass pipe fittings and have trouble getting good clean castings. The molds look clean and are rammed properly. The sand is not too wet, but still the castings come out with little spots on the cope sides of the castings. The spots sometimes look like sand spots and again they look like oxide. The mixture is 85, *three* 5's *with a small addition of* 15 *per cent phosphor-copper. What is the proper amount of phosphor-copper to add to this alloy, and is the alloy the cheapest we can use for this class of work? We are melting in indirect arc furnaces but do not use a covering over the brass. Our losses are running over 75 per cent, which is entirely too much. Can you suggest anything?*

An alloy of 83 per cent copper, 4 per cent tin, 6 per cent lead, and 7 per cent zinc would be cheaper and just as good as the one being used. The proper amount of 15 per cent phosphor-copper is small, we have found through experience of 40 years, and we suggest the addition of 1½ ounces per hundred pounds of brass. We have not the slightest idea as to what causes the spots. There are so many figures in the equation unknown to us. Thus, for instance, it may be your brass is *irony* as its source is not told in the query. If it is supplied by *General Junk*, we would be suspicious of the gentleman, for it is a matter of common knowledge that he is never happy except when getting an honest foundryman to combine making of castings and smelting of metal. That only pays under exceptional conditions. Probably if several heats were taken off, using nothing except new or virgin copper, tin, lead and zinc, that the troublesome spots would be conspicuous by their absence.

It will not be necessary to use all new metals in future work, as doing such a thing probably would close up the foundry in the near future. New metal should be used for a number of heats simply to determine, or attempt to determine where the blame may be. After that is definitely known, the proper course to follow to determine the correct amount of scrap to use will be apparent.

Readers Comment

Note—Material appearing under this head does not necessarily reflect the opinion of THE FOUNDRY or of its editors.

TO THE EDITORS:

Answering a query regarding glass factory molds you stated in part, in a recent issue of THE FOUNDRY: "No person has succeeded in developing an iron which would produce a mold soft enough to machine readily, hard enough to impart a smooth finish to the glass and tough enough to resist alternate contraction and expansion."

After experimenting several years, we finally have developed an iron which produces mold castings which machine freely at high speed and at the same time is a dense, close grain iron free from all defects ordinarily found in mold castings. This iron also takes a splendid polish, a feature absolutely essential as the surface of the mold which comes into contact with the glass must be smooth, free from pin holes and must be highly polished to impart a smooth finish to the glass. We have eliminated brittleness entirely. In service the exansion or *growth* as it is known in the shop, is scarcely noticeable. We are in a position to furnish glass manufacturers with mold castings entirely satisfactory in every respect. To demonstrate our ability to produce high-class mold castings we shall be glad to receive patterns from glass manufacturers and make up one or two sample castings free of charge.

A. E. DEGRAND.
Secretary-treasurer,
Alton Foundry Co.,
Alton, Ill.

Using Iron Bearings

TO THE EDITORS:

Use of cast iron bearings was discussed in a recent issue of THE FOUNDRY. I have made a great many cast iron bearings in various sizes during the past year and they have given excellent satisfaction in service and in reducing cost of maintenance. They were tried first experimentally to replace brass bearings on mill table rollers. Operated under exactly the same conditions and lubricated daily, these cast iron bearings have been in continuous use for 9 months. The roller necks are smooth and free from grooves and the bearings apparently are good for considerable further service. Some of these castings have been machined and others have been placed in service in the condition in which they left the foundry. Experience has shown that where the bearings are subjected to shock, any side play must be avoided. We also have used cast iron bearings to replace brass bearings for rolls on several mills. Results have been quite gratifying. Where the service is not too severe cast iron can be used in many places to replace the expensive nonferrous bearings usually employed.

A. E. FORSBERG.
Foundry superintendent,
Wheeling Steel Corp.,
Portsmouth, O.

Cook Disagrees

TO THE EDITORS:

You asked for my photograph a long time ago and somehow I never got around to sending it to you.

Enclose my latest.

MR. MILLER DE LA FUNDICION DE BRONCE DE TORREON.

My cook (Mexican) in commenting on it says it is not well done for I have not got big feet.

H. H. MILLER.
Miller Brass Foundry,
Torreon, Coah., Mexico.

Note: Mr. Miller frequently has been invited to send his photograph to THE FOUNDRY. His compliance, while not to be taken seriously, affords an opportunity we have long sought. Perhaps this will serve as a warning to others who are reluctant to supply a bona fide likeness on request.

The caricature here reproduced appeared in a Mexican paper which is running a series of drawings of noteworthy people. The caption describes Mr. Miller as the proprietor of the Miller Brass Foundry—THE EDITORS.

M. K. Epstein will sell the oil burning equipment made by Gilbert & Barker Mfg. Co., Springfield, Mass., at the Springfield, Mass., office.

Gives Practical Hints on Aluminum Bronze

Foundrymen who desire to learn more about the practical handling of aluminum bronze will be interested in the 76-page booklet recently published by the British Aluminum Co. Ltd., London, Eng. One section of the booklet is devoted to foundry technique and covers such topics as self-annealing, casting defects, their cause and remedy, melting practice, pouring temperature, molding sand, gating, risers, chills and knocking out. Another section deals with the influence of other metals and discusses the effects of adding small amounts of iron, nickel, manganese and lead. Heat treatment is described in Section IV, while Section V presents some notes on diecasting. This section covers such points as materials for dies, core materials, mold design, die operation, mold temperature, and metal temperature. Tables giving the properties of aluminum bronze are included.

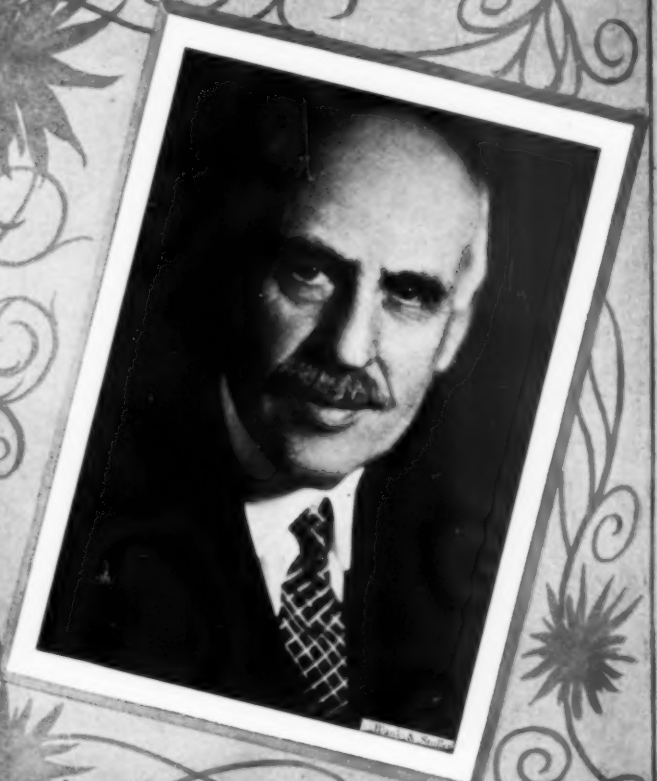
Indianapolis Foundrymen Elect Officers

Indianapolis Foundrymen's association elected Frank S. O'Neil, manager of the Indianapolis plant of the Link-Belt Co., president for 1929 at a recent meeting. Guy E. Street, American Foundry Co., was re-elected vice president, and James H. Hooker, Sinker-Davis Co., treasurer. Andrew J. Allen was elected secretary for the sixteenth year. T. J. Cornwell, Peerless Foundry Co., and J. B. Lewis, Federal Foundry Co., were re-elected to the executive committee.

Publishes Yearbook

The third issue of the Standards Yearbook just has been published by the national bureau of standards, Washington. It contains descriptions of the activities of the national bureau of standards and other agencies of the federal government, states, counties and municipalities, technical societies and trade associations with special emphasis on their accomplishments during 1928. The book also contains an outline of methods employed in standardizing commercial weights and measures and a description of an attempt to simplify the calendar by adding an international month. Copies of the publication which is bureau of standards, miscellaneous publication No. 91 may be obtained from the superintendent of documents, government printing office, Washington, for $1.

The FOUNDRY Family Photograph Album



Upper Left

T. E. HENRY
Henry Furnace & Foundry Co., Cleveland

Lower Left

G. A. T. LONG
Pickands, Brown & Co., Chicago

Upper Right

W. A. LEONARD
Imperial Brass Mfg. Co., Chicago

Lower Right

RALPH DITTY
Federal Foundry Supply Co., Cleveland

SCRAP METAL SPECIFICATIONS

(*Continued from Data Sheet No. 756*)

Hydraulically Compressed Sheet Scrap

Hydraulically compressed steel scrap will consist of new, black steel sheet clippings, shearings, skeleton stamping scrap, side and end sheet and tin-mill scrap, hydraulically compressed into compact, rectangular packages not to exceed 20 inches longest dimension, weighing not less than 75 pounds per cubic foot; must be clean and free from excessive rust, paint, or protective coating of any kind. No detinned scrap, electrical sheets, or material over 0.50 per cent silicon will be accepted. Further limitation of silicon content may be made by mutual agreement between buyer and seller.

Baled Sheet Scrap

Baled sheet scrap will consist of new, black steel sheet clippings, shearings, skeleton stamping scrap, side and end sheet and tin-mill scrap, machine baled into angular or rectangular packages, tied with wire or bands, or sufficiently compact not to come apart in handling with a magnet, not over 24 inches longest dimension, weighing not less than 45 pounds per cubic foot; must be clean and free from excessive rust, paint, or protective coating of any kind. No detinned scrap, electrical sheets, or material over 0.50 per cent silicon will be accepted. Further limitation of silicon content may be made by mutual agreement between buyer and seller.

Hand Bundled Sheet Scrap

Hand bundled sheet scrap will consist of new, black steel clippings, shearings, skeleton stamping scrap, side and end sheet and tin-mill scrap, securely tied with not less than two wires or bands into packages not over 18 x 18 inches x 3 feet, weighing not over 125 pounds, to be bundled in such a manner that packages will not come apart in handling with a magnet; must be clean and free from excessive rust, paint, or protective coating of any kind. No detinned scrap, electrical sheets, or material over 0.50 per cent silicon will be accepted. Further limitation of silicon content may be made by mutual agreement between buyer and seller.

Loose Sheet Clippings

Loose clippings will consist of new, black steel sheet clippings, shearings and stampings, 3/16-inch and lighter, free from excessive rust, paint, or protective coating of any kind, to be not over 18 inches wide or long, or if edge trimmings or shearings to be not over 12 inches x 5 feet. No detinned scrap, electrical sheets, or material over 0.50 per cent silicon will be accepted. Further limitation of silicon content may be made by mutual agreement between buyer and seller.

(*Continued on Data Sheet No. 758*)

SCRAP METAL SPECIFICATIONS

(*Continued from Data Sheet No. 757*)

Galvanized or Coated Sheet Scrap

Galvanized or coated sheet scrap will consist of new, clean steel sheet scrap, composed in whole or in part of material having a coating of zinc, paint, or protective material. Must be clearly specified as "galvanized or coated scrap" and be classified as above under No. 1 busheling, No. 2 bundling, No. 1 selected rail scrap or No. 1 selected shearing scrap, according to the manner in which it is prepared for shipment. No material over 0.50 per cent silicon will be accepted. Further limitation of silicon content may be made by mutual agreement between buyer and seller.

Detinned Sheet Scrap

Detinned sheet scrap will consist of sheet steel clippings and shearings, originally covered with a protective coating of tin or lead and tin, but from which such foreign metals have been removed. Must be clean, contain no material over 0.50 per cent silicon and be free from badly rusted and corroded stock. Must be specified clearly as *detinned scrap* and classified as above under No. 1 busheling, No. 2 busheling, No. 1 selected rail scrap or No. 1 selected shearing scrap, according to the manner in which it is prepared for shipment. Further limitation of silicon content may be made by mutual agreement between buyer and seller.

Electrical Sheet Scrap

Electrical sheet scrap will consist of new, clean steel sheet scrap, composed in whole or in part of material from 0.50 per cent to 1 per cent silicon. Must be specified clearly as *electrical sheet scrap* and be classified as above under No. 1 busheling, No. 2 busheling, No. 1 selected rail scrap or No. 1 selected shearing scrap, according to the manner in which it is prepared for shipment.

High Silicon Sheet Scrap

High silicon sheet scrap will consist of new, clean steel sheet scrap, composed in whole or in part of material over 1 per cent silicon. Must be specified clearly as *high silicon sheet scrap* and be classified as above under No. 1 busheling, No. 2 busheling, No. 1 selected rail scrap or No. 1 selected shearing scrap, according to the manner in which it is prepared.

No. 1 Cast-Iron Scrap

No. 1 cast-iron scrap will contain all kinds of machinery and similar cast-iron scrap, nothing under 10 pounds or over 500 pounds in weight nor over 48 inches long or 18 inches wide. To contain no brake shoes, cast-iron soil or water pipe, stove scrap, or burnt iron of any description, and be free from steel parts.

(*Continued on Data Sheet No. 759*)

THE FOUNDRY DATA SHEET, MARCH 15, 1929

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Measure Temperature OF *MOLTEN CAST IRON*

By H. T. Wensel and W. F. Roeser

Part II

SEVEN distinct types of cast iron, as shown in Table VII, were investigated in the experimental foundry of the bureau. The iron was melted in a 300-pound capacity electric arc furnace. To obtain the corrections for streams, a thermocouple was held in the iron in the furnace while the optical pyrometer was sighted on the stream flowing out of the furnace into a ladle. Previous experiments had indicated that the difference in temperature between the iron in the furnace and in the stream was of the order of 10 degrees Cent. No correction was made for this.

Give Corrections

THIS is the second and concluding article on the measurement of molten cast iron temperatures, in which the authors give the results obtained in measuring temperatures of seven different types of cast iron, and show the necessary corrections to give readings when using optical type pyrometers. The articles are abstracted from a paper presented at the Philadelphia convention of the American Foundrymen's association.

The optical pyrometer was sighted on the stream from the front, there being no smoke whatever present during any of the observations reported.

As soon as the ladle was filled, the thermocouple was transferred to it and simultaneous readings taken with the thermocouple and the optical pyrometer as the iron in the ladle cooled. The depth of immersion of the couple in the ladle was from 6 to 10 inches. Observations on streams at low temperatures were obtained by holding the couple in the ladle while the optical pyrometer was sighted on the stream flowing into a mold, pig bed, or back into the furnace.

To determine whether the depth of

Table V

Corrections in Degrees Centigrade

Molten Cast Iron ($\lambda = 0.65\ \mu$)

Apparent Temperature Deg. C.	—Below Transition Point— True Temp. Deg. C.	Correction Deg. C.	—Above Transition Point— True Temp. Deg. C.	Correction Deg. C.
1160	1194	34	.....	.....
1180	1215	35	.....	.....
1200	1236	36	.....	.....
1220	1257	37	.....	.....
1240	1278	38	.....	.....
1260	1299	39	1365	105
1280	1320	40	1387	107
1300	1341	41	1410	110
1320	1362	42	1433	113
1340	1383	43	1456	116
1360	1404	44	1479	119
1380	.....	....	1502	122
1400	.....	....	1526	126
1420	.....	....	1549	129
1440	.....	....	1572	132
1460	.....	....	1595	135

Table VI

Corrections in Degrees Fahrenheit

Molten Cast Iron ($\lambda = 0.65\ \mu$)

Apparent Temperature Deg. F.	—Below Transition Point— True Temp. Deg. F.	Correction Deg. F.	—Above Transition Point— True Temp. Deg. F.	Correction Deg. F.
2120	2181	61	.....	.....
2156	2219	63	.....	.....
2192	2257	65	.....	.....
2228	2295	67	.....	.....
2264	2332	68	.....	.....
2300	2370	70	2489	189
2336	2408	72	2529	193
2372	2446	74	2570	198
2408	2484	76	2611	203
2444	2521	77	2653	209
2480	2559	79	2694	214
2516	.....	....	2736	220
2552	.....	....	2779	227
2588	.....	....	2820	232
2624	.....	....	2862	238
2660	.....	....	2903	243

Table VII

Chemical Compositions of Cast Irons

	Ordinary Cast				Low Carbon		Nickel Cast: Low Nickel		Nickel Cast: Med. Nickel	Nickel Cast: High Nickel	Nil-Cr Cast: Low Ni-Cr	Nil-Cr Cast: High Ni-Cr
	1	2	3	4	5	12	6	9	7	10	8	11
Total carbon	3.54	3.35	3.40	3.33	3.10	2.48	3.25	3.40	3.40	3.40	3.10	3.30
Graphite carbon	2.83	2.65	2.75	2.70	0.01	1.90	3.14	3.03	2.68	3.17	2.86	2.61
Combined carbon	0.71	0.70	0.64	0.63	3.09	0.58	0.11	0.37	0.72	0.23	0.72	0.69
Manganese	0.20	0.72	0.25	0.26	0.49	0.56	0.73	0.72	0.71	0.65	0.68	0.69
Phosphorus	0.505	0.505	0.510	0.810	0.345	0.380	0.515	0.490	0.515	0.480	0.495	0.470
Sulphur	0.032	0.034	0.020	0.023	0.120	0.037	0.043	0.039	0.036	0.038	0.029	0.035
Silicon	1.52	2.16	1.18	2.10	0.44	1.39	2.27	2.23	2.29	2.25	1.87	2.15
Nickel	.....	.....	.....	.....	0.06	.....	0.51	0.52	1.35	2.99	1.34	2.95
Chromium	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.56	0.95

Table VIII

Bureau of Standards Foundry Readings

Type of Iron	Thermocouple Deg. Cent.	Optical Deg. Cent.	Difference Deg. Cent.
Ordinary Cast, Runs 1 to 5, inclusive	1170 (2)	1134 (2)	36
Ordinary Cast, Runs 1 to 5, inclusive	1232 (3)	1195 (3)	37
Ordinary Cast, Runs 1 to 5, inclusive	1254 (4)	1211 (4)	43
Ordinary Cast, Runs 1 to 5, inclusive	1272 (3)	1221 (3)	51
Ordinary Cast, Runs 1 to 5, inclusive	1289 (4)	1243 (4)	46
Ordinary Cast, Runs 1 to 5, inclusive	1312 (4)	1248 (4)	64
Ordinary Cast, Runs 1 to 5, inclusive	1345 (6)	1281 (6)	64
Ordinary Cast, Runs 1 to 5, inclusive	1375 (2)	1291 (2)	84
Ordinary Cast, Runs 1 to 5, inclusive	1408 (2)	1311 (2)	97
Ordinary Cast, Runs 1 to 5, inclusive	1422 (7)	1321 (7)	101
Ordinary Cast, Runs 1 to 5, inclusive	1449 (3)	1340 (3)	109
Ordinary Cast, Runs 1 to 5, inclusive	1466 (2)	1357 (2)	109
Ordinary Cast, Runs 1 to 5, inclusive	1507 (4)	1383 (4)	124
Ordinary Cast, Runs 1 to 5, inclusive	1534 (2)	1404 (2)	130
Ordinary Cast, Runs 1 to 5, inclusive	1574 (2)	1446 (2)	128
Ordinary Cast, Runs 1 to 5, inclusive	1659 (1)	1525 (1)	134
Low Carbon, Run 12	1303 (3)	1246 (3)	57
Low Carbon, Run 12	1339 (1)	1270 (1)	69
Low Carbon, Run 12	1523 (3)	1400 (3)	123
Low Carbon, Run 12	1602 (5)	1455 (5)	147
Low Nickel, Runs 6 and 9	1338 (2)	1294 (2)	44
Low Nickel, Runs 6 and 9	1399 (2)	1293 (2)	106
Low Nickel, Runs 6 and 9	1458 (4)	1340 (4)	118
Low Nickel, Runs 6 and 9	1504 (4)	1386 (4)	118
Low Nickel, Runs 6 and 9	1532 (1)	1410 (1)	122
Low Nickel, Runs 6 and 9	1576 (5)	1436 (5)	140
Medium Nickel, Run 7	1199 (1)	1140 (1)	59
Medium Nickel, Run 7	1298 (2)	1234 (2)	64
Medium Nickel, Run 7	1445 (2)	1337 (3)	108
Medium Nickel, Run 7	1510 (2)	1400 (2)	110
High Nickel, Run 10	1233 (2)	1163 (2)	70
High Nickel, Run 10	1416 (2)	1315 (2)	101
High Nickel, Run 10	1509 (3)	1390 (3)	119
Medium Nickel-Chrome, Run 8	1375 (2)	1300 (2)	75
Medium, Nickel-Chrome, Run 8	1400 (3)	1289 (3)	111
Medium Nickel-Chrome, Run 8	1456 (3)	1327 (3)	129
Medium Nickel-Chrome, Run 8	1629 (3)	1485 (3)	144
High Nickel-Chrome, Run 11	1229 (2)	1164 (2)	65
High Nickel-Chrome, Run 11	1572 (2)	1440 (2)	132
High Nickel-Chrome, Run 11	1601 (3)	1466 (3)	135

Note: The figures in parentheses indicate the number of readings which were averaged to obtain the corresponding temperatures.

immersion was sufficient, the thermocouple was immersed 4½ inches in molten copper. The thermocouple at this depth of immersion indicated within 1 degree the correct freezing point of the copper.

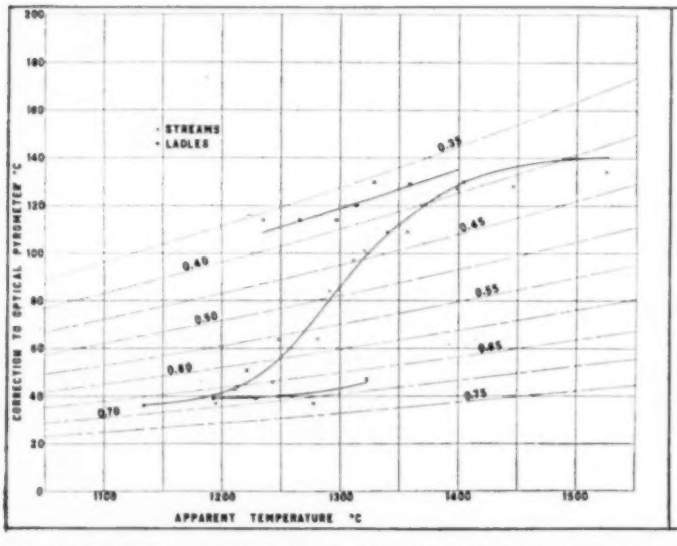
Thermocouples and optical pyrometers used in the tests at Lynchburg and Birmingham were calibrated both before and after the tests. One of the couples used at Birmingham changed 5 degrees in calibration, a pro-rata correction being made for this. In the work done at the bureau, all the measuring apparatus used was calibrated before and after each run. The maximum change observed was 4 degrees in the case of a couple which had been used above 1600 degrees Cent. Usually the change was about 2 degrees Cent.

As a ladle of cast iron is allowed to cool from 1500 to 1300 degrees Cent. true temperature, a marked increase in the surface brightness occurs. This change occurred in all the irons investigated at nearly the same temperature, approximately 1375 degrees thermocouple reading. In some cases the change was abrupt, the transition from a surface of the uniformly low emissivity to a surface of uniformly high emissivity taking place within ten or 15 seconds.

If the bright surface, apparently a solid skin on top of the molten iron, was removed by skimming, the surface would be temporarily *dark* but would again become uniformly bright usually before a satisfactory optical reading could be obtained. The phenomenon is striking, the increase in brightness being almost 100 per cent. In other cases, bright patches would begin to appear and slowly spread to cover the entire surface. In such cases, readings were taken on both the bright and the dark portions for temperatures somewhat below the transition point.

In one case, runs 6 and 9 on low nickel iron, the dark and bright portions persisted side by side from about 1375 degrees down to the end of the run. This behavior probably caused the difficulty mentioned by the American Foundrymen's association in their request that this type of iron be included in our work. At the lower temperatures the brightest portions were observed, although these were usually streaked with dark. The optical readings on these runs are consequently lower than would have been obtained if clear patches of bright surface had been observed.

In the case of the high and medium nickel irons, with or without chromium



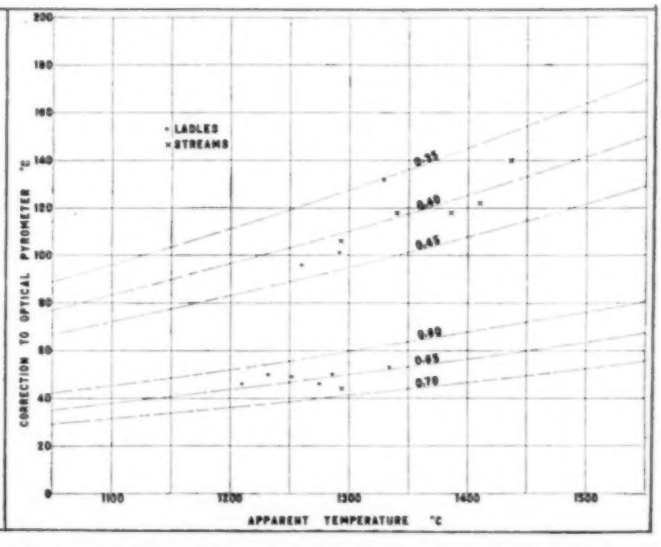


FIG. 3—RESULTS OF TESTS AT THE BUREAU OF STANDARDS ON ORDINARY CAST IRON. THE BROKEN LINES REPRESENT THE CORRECTIONS CORRESPONDING TO THE INDICATED EMISSIVITY VALUES FOR WAVE-LENGTH 0.65 MICRON. FIG. 4—RESULTS OF TESTS AT THE BUREAU OF STANDARDS ON CAST IRON CONTAINING 0.5 PER CENT NICKEL. BROKEN LINES SAME AS IN FIG. 3

runs 7 and 8, 10 and 11, the transition was sharp, the surface being uniformly bright from 1375 degrees down to 1250 degrees, at which point the bright surface began to break up into dark and bright regions. Here observations were made on both dark and bright portions but only the *bright* readings are reported. The slight increase in the corrections at the lowest points of runs 8 and 11 are probably due to the fact that in these cases the bright film grew thick toward the end of each run and an appreciable temperature difference may have existed between the top and bottom of the film.

The temperature measurements obtained in the bureau foundry are shown in Tables VIII and IX. Two sample runs are given graphically in Figs. 3 and 4 to show the discontinuity in the correction curve. In Figs. 5 and 6 are plotted all the data shown in Tables VIII and IX.

It will be noted that in Fig. 3, the corrections to be applied to streams do not show a sharp break. This may be explained by supposing that the surface observed is a mixture of light and dark portions, the result being the same as would be obtained if a ladle of the iron were vigorously stirred so as to keep the surface broken up. Above the transition point the surface is, of course, *dark*. At low temperatures the corrections for the stream approach those for ladles. The streams observed at the bureau were comparatively small and irregular. In large, steady streams, such as were viewed at Birmingham, the stirring action of the stream would be less and here the corrections are no larger than for ladles.

In streams of high nickel and nickel-chrome irons, large areas of uniformly

Table IX

Readings on Seven Types of Cast Iron

Type of Iron	Thermocouple Deg. Cent.	Optical Deg. Cent.	Difference Deg. Cent.
Ordinary Cast, Runs 1 to 5, inclusive	1232 (4)	1193 (4)	39
Ordinary Cast, Runs 1 to 5, inclusive	1268 (4)	1229 (4)	39
Ordinary Cast, Runs 1 to 5, inclusive	1288 (4)	1248 (4)	40
Ordinary Cast, Runs 1 to 5, inclusive	1300 (4)	1260 (4)	40
Ordinary Cast, Runs 1 to 5, inclusive	1315 (5)	1278 (5)	37
Ordinary Cast, Runs 1 to 5, inclusive	1349 (4)	1235 (4)	114
Ordinary Cast, Runs 1 to 5, inclusive	1370 (4)	1323 (4)	47
Ordinary Cast, Runs 1 to 5, inclusive	1380 (4)	1266 (4)	114
Ordinary Cast, Runs 1 to 5, inclusive	1411 (4)	1297 (4)	114
Ordinary Cast, Runs 1 to 5, inclusive	1434 (4)	1314 (4)	120
Ordinary Cast, Rune 1 to 5, inclusive	1459 (4)	1329 (4)	130
Ordinary Cast, Runs 1 to 5, inclusive	1488 (4)	1359 (4)	129
Ordinary Cast, Runs 1 to 5, inclusive	1526 (4)	1399 (4)	127
Low Carbon, Run 12	1312 (3)	1272 (3)	40
Low Carbon, Run 12	1347 (3)	1302 (3)	45
Low Carbon, Run 12	1378 (3)	1323 (3)	55
Low Carbon, Run 12	1404 (3)	1283 (3)	121
Low Carbon, Run 12	1407 (2)	1354 (2)	53
Low Carbon, Run 12	1448 (3)	1317 (3)	131
Low Carbon, Run 12	1490 (4)	1350 (4)	140
Low Carbon, Run 12	1537 (3)	1394 (3)	143
Low Nickel, Runs 6 and 9	1256 (3)	1210 (3)	46
Low Nickel, Runs 6 and 9	1282 (3)	1232 (3)	50
Low Nickel, Runs 6 and 9	1301 (3)	1252 (3)	49
Low Nickel, Runs 6 and 9	1321 (3)	1275 (3)	46
Low Nickel, Runs 6 and 9	1336 (3)	1286 (3)	50
Low Nickel, Runs 6 and 9	1356 (3)	1260 (3)	96
Low Nickel, Runs 6 and 9	1387 (4)	1334 (4)	53
Low Nickel, Runs 6 and 9	1393 (4)	1292 (4)	101
Low Nickel, Runs 6 and 9	1461 (4)	1329 (4)	132
Medium Nickel, Run 7	1207 (3)	1172 (3)	35
Medium Nickel, Run 7	1251 (3)	1204 (3)	47
Medium Nickel, Run 7	1294 (3)	1234 (3)	60
Medium Nickel, Run 7	1316 (3)	1264 (3)	52
Medium Nickel, Run 7	1332 (4)	1275 (4)	57
Medium Nickel, Run 7	1353 (3)	1302 (3)	51
Medium Nickel, Run 7	1368 (4)	1320 (4)	48
Medium Nickel, Run 7	1374 (4)	1274 (4)	100
Medium Nickel, Run 7	1402 (3)	1346 (3)	56
Medium Nickel, Run 7	1411 (4)	1303 (4)	108
High Nickel, Run 10	1246 (4)	1224 (4)	22
High Nickel, Run 10	1319 (3)	1278 (3)	41
High Nickel, Run 10	1368 (3)	1330 (3)	38
High Nickel, Run 10	1417 (1)	1303 (1)	114
Medium Nickel-Chrome, Run 8	1282 (3)	1245 (3)	37
Medium Nickel-Chrome, Run 8	1307 (3)	1275 (3)	32
Medium Nickel-Chrome, Run 8	1337 (4)	1308 (4)	29
Medium Nickel-Chrome, Run 8	1368 (3)	1331 (3)	37
Medium Nickel-Chrome, Run 8	1390 (3)	1285 (3)	105
Medium Nickel-Chrome, Run 8	1429 (3)	1319 (3)	110
Medium Nickel-Chrome, Run 8	1474 (3)	1347 (3)	127
Medium Nickel-Chrome, Run 8	1529 (3)	1394 (3)	135
High Nickel-Chrome, Run 11	1255 (3)	1207 (3)	48
High Nickel-Chrome, Run 11	1273 (3)	1233 (3)	40
High Nickel-Chrome, Run 11	1291 (3)	1258 (3)	33
High Nickel-Chrome, Run 11	1306 (3)	1283 (3)	23
High Nickel-Chrome, Run 11	1334 (4)	1306 (4)	28
High Nickel-Chrome, Run 11	1371 (3)	1327 (3)	44
High Nickel-Chrome, Run 11	1389 (3)	1349 (3)	40
High Nickel-Chrome, Run 11	1418 (3)	1310 (3)	108
High Nickel-Chrome, Run 11	1442 (3)	1333 (3)	109
High Nickel-Chrome, Run 11	1468 (3)	1354 (3)	114
High Nickel-Chrome, Run 11	1518 (2)	1387 (2)	131

Note: The figures in parentheses indicate the number of readings which were averaged to obtain the corresponding temperatures.

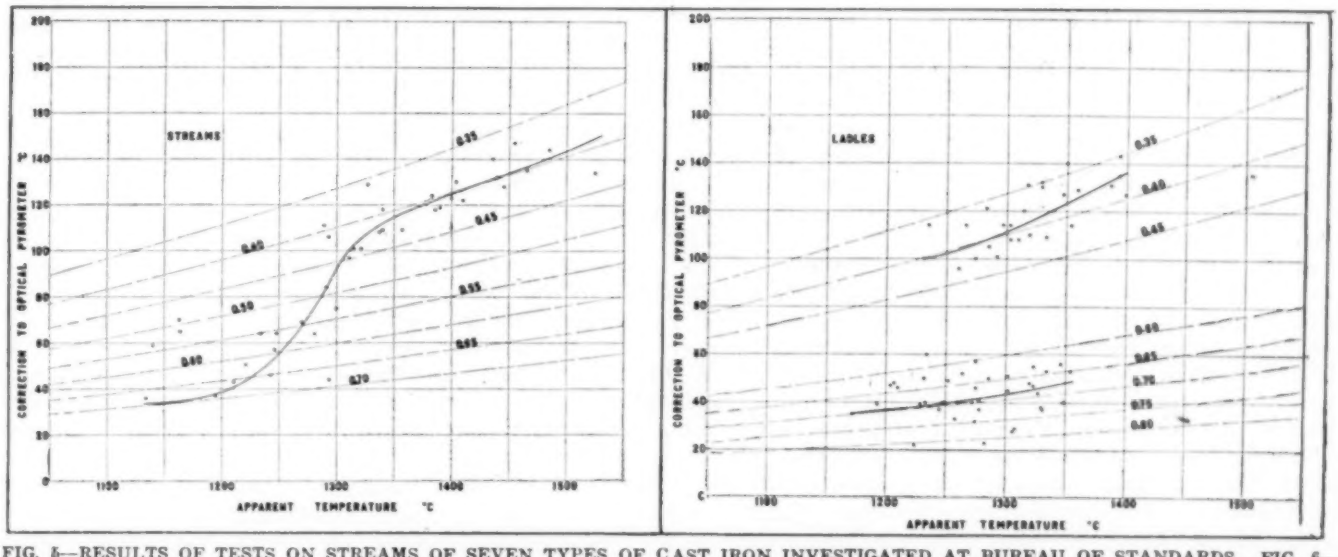


FIG. 5—RESULTS OF TESTS ON STREAMS OF SEVEN TYPES OF CAST IRON INVESTIGATED AT BUREAU OF STANDARDS. FIG. 6—RESULTS OF TESTS ON LADLES OF SEVEN TYPES OF CAST IRON INVESTIGATED AT BUREAU OF STANDARDS. BROKEN LINES REPRESENT CORRECTIONS CORRESPONDING TO INDICATED EMISSIVITY VALUES FOR WAVE-LENGTH 0.65 MICRON

high and low brightness could be distinguished side by side, these being the irons in which the bright skin formed quickly and hung together apparently as a comparatively tough solid film. The temperature range in which this could be observed on streams of these irons was comparatively narrow and the temperature of the stream could be estimated within a few degrees in this region merely by noting the presence of the bright patches among the dark.

While it is comparatively easy to establish the change in surface emissivity around 1375 degrees Cent. on cast irons, the explanation of the phenomenon is more difficult. One can only form a conjecture as to the composition of the surface. The transition may be from liquid to solid oxide or from liquid to solid slag. The emissivities around 0.4 obtained in this work at the higher temperatures, however, seem to indicate that there we are dealing with a clean iron surface. At lower temperatures it is probably that the surface is made up to a large extent, if not entirely, of iron oxides.

Silicon Oxidized First

It is a familiar fact that in normal bessemer blows, silicon is first oxidized and then carbon, while in blows that start at an initially high temperature, the silicon is eliminated after the carbon. Similarly in a basic open hearth heat, normally the phosphorus is taken out first and then the carbon, but by beginning a heat at a high initial temperature, the carbon may be removed first. This points to the fact that the oxidation of the carbon in cast iron takes place to a large extent at high temperatures. This, occurring at the surface, might produce conditions sufficiently reducing to maintain a surface of metallic iron. At lower temperatures, the oxidation of the carbon taking place to a negligible extent would permit the oxide to form on the surface.

Another explanation offered is that the transition at 1375 degrees Cent. is from liquid to solid iron oxides. While the melting point of the various oxides of iron are all higher than this, we undoubtedly are dealing with a mixture or solution of FeO in Fe_2O_3 as shown by the work of Sosman and Hostetter. It is likely that a eutectic would be formed, melting in the neighborhood of 1375 degrees. However, the emissivity values obtained above this point indicate that here we have metallic iron. Perhaps the best explanation is that the solid oxide formed below 1375 degrees is comparatively insoluble in molten iron, while the molten oxide formed above this point goes into solution as fast as it forms.

With a little practice and judgment it is possible to determine when the iron is above or below the transition point without seeing the actual transition. The bright surface, below the transition point, is distinctly yellow and has a matte appearance, while above this point the iron has a mirror surface with a slightly greenish tinge. Where both bright and dark are present on a ladle, of course, no confusion should result, and when the surface is streaky, the correction made should be intermediate between large and small. In any case one always can skim off the surface and note how the brightness of the metal underneath compares with that of the surface which has been measured.

Where iron of a given composition is poured day after day the optical pyrometer should not give any serious trouble even in the transition range, provided the operator knows about the transition phenomenon and is on his guard.

The corrections to be added to apparent temperatures in order to obtain true temperatures will be found summarized in Tables VIII and IX.

So far no work has been done on steels, but an analogous condition exists here. In fact, it was a knowledge of a similar phenomenon occurring at a higher temperature in the case of steels which, to some extent, led to the method of investigation adopted here. It is hoped to take up the problem of optical pyrometer measurements on steel in the near future.

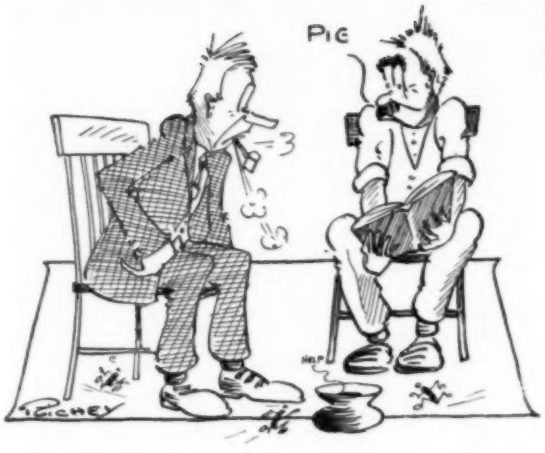
Draw Conclusions

Measurements of the true temperature with a thermocouple and apparent temperature with an optical pyrometer on molten cast iron show that the character of the surface undergoes a change in the neighborhood of 1375 degrees Cent. true temperature. Observations on streams and ladles in the bureau of standards foundry and in commercial plants all indicate that the uncorrected optical pyrometer reading is approximately 40 degrees Cent. lower than the true temperature below 1375 degrees Cent. when the bright presumably oxidized surface is observed. This corresponds to an emissivity of 0.7 in this region. Above this region the emissivity is approximately 0.4, corresponding to a correction of 110 degrees at 1400 degrees Cent. and 140 degrees at 1600 degrees Cent. true temperature.

The change in emissivity is attributed to the formation of iron oxide below 1375 degrees Cent. Above this temperature the difference between true and apparent temperature corresponds to the emissivity found for pure iron in the laboratory.

Gives Business Forecast

Hougland & Hardy, Evansville, Ind., dealers in foundry sand, recently made a survey of anticipated foundry business in the United States. The company sent out 754 inquiries and received 356 answers, a return of 47 per cent. The territory covered extended from Los Angeles east to Cleveland, and from the Canadian line on the north to the Gulf of Mexico on the south. However, the majority of inquiries were sent to foundries in Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, Indiana, Kentucky, Tennessee, Alabama, Georgia, and a few to Louisiana. The results of the survey show that the majority of foundrymen believe that the foundry industry will enjoy a prosperous year during 1929 with the south anticipating the largest increase in volume. In the northern states increases of from 5 to 50 per cent were anticipated with an average expected increase of 17 per cent; in the central states 5 to 100 per cent increases in business were forecast with an average of 23 per cent; the southern states anticipated increases of from 2 to 100 per cent with an average of 26 per cent. The survey shows further that 68 per cent of the foundries answering the questionnaires believed that business for 1929 would be better than in the previous year, 31 per cent were of the opinion that business would be about the same and only 1 per cent expected a decrease in business. Of the different classes of foundries, all of those making plumbing goods, furnaces and fittings were of the opinion that 1929 would be a better business year than 1928. A like opinion was held by 73 per cent of the jobbers, 56 per cent of the stove and range makers, 77 per cent of the malleable foundries, 63 per cent of the machinery manufacturers, 43 per cent of the brass makers, 50 per cent of the foundries making car wheels, 66 per cent of the farming implement manufacturers and 78 per cent of the miscellaneous and specialty manufacturers. According to the survey the brass foundries were the least optimistic of any of the various manufacturers mentioned, 56 per cent being of the opinion that business this year would be about the same as last. However, as a whole, the foundry industry solicited in the survey was extremely optimistic concerning the business outlook for 1929.



Bill Learns Something New About Pigs

By Pat Dwyer

BILL failed to share my enthusiasm when I showed him a copy of a fine new dictionary I recently acquired. He claimed that too many words are in existence. The world would be a better place in which to live if the present mess of words was chucked into the sea and the people were allowed to start again at par. With a grand new book containing hundreds, yes thousands of words to which previously I had been a stranger, I could not countenance a statement of that kind.

"The trouble," I said, "with the English language is not that it contains too many words, but that too many people insist on using one word to cover forty different objects, thoughts, or what have you. I suppose other languages are man-handled in the same manner, but since I am not familiar with any of them I am not going to venture an opinion or set up as an authority.

"So far as my limited opportunities have shown me, primitive, barbarous, or semicivilized people have the most simple and satisfactory languages. Their vocabulary is limited to a comparatively few words. Each of these words has a definite meaning. When a man uses a certain word, his hearers catch the exact meaning of the thought he wishes to convey. Take any common word that comes readily to mind and I'll show you what I mean. For example, there is the word *pig*. That is about as common a name for as common an animal as you'll find in a long day's walk. In its application and use it presents more curls and twists than are found in the tail of the piggiest pig that ever sported a hand curled tail." "Nonsense," Bill exclaimed. "A pig is a pig. To a farmer it is an animal. To a foundryman it is a hunk of metal. The word has two meanings, that's all."

"Easy, my lad," I cautioned, "easy is the word. You are riding for a fall. Throw your mind—temporarily—to one of the sunny South sea isles where a gorgeous, hand painted warrior and his collection of assorted wives, done in more modest tints, are reclining at ease during the morning hours. The chief, in his capacity of good provider for the family, suddenly remembers that the larder is empty. He fixes his glittering eye on one of the wives who, at the moment, happens to be in the black book for some sin of omission or commission. He barks the one word 'Pig!'

"If that happened in one of our highly civilized communities, where single words may be interpreted in a dozen or more different ways, the lady possibly might construe the remark as a personal reflection on her good looks, her habits or her appetite. Since she merely is an untutored savage, accustomed to treating words in their naked simplicity, she grasps his meaning instantly. She accepts the word as a command to go forth into the bush to secure a pig for the family table. No quibbling, no arguing, no useless waste of time and conversation.

"She tightens her belt; takes a fresh chew of gum or tobacco or betel nut, depending on her personal choice and—to some extent on her opportunities—assumes an air of haughty indifference and departs on her errand. She knows if she does not bring back a pig, her lord and master may decide to—er—what shall we say—utilize a substitute.

"The famous saying, credited to a Spartan mother 'Come back with your shield or on it' probably originated at a much earlier period in the world's history when the hairy old head man of the community sent one of his gang into the wilderness with the terse and friendly command: 'Bring back a pig if you can, but don't forget to come back!'

"Bring your mind back now from the dreamy atolls, coral reefs and the ideal existence of those who toil not, neither do they spin and who consequently are better off than Solomon in all his worries. Bring your mind back to this identical town in this day and generation and in imagination come with me to the home of that well known citizen John Doe or his equally famous running mate Richard Roe. These two precious lads gave me a pain in the neck during my school days. Every day I found them in a new jam, tangled up in invoices, bills of sale, statements, checks, drafts, and interest at 4½ per cent from May 3 to Nov. 11 inclusive in the same year. For the foregoing reason I have no hesitancy now in taking you with me secretly into the home of either one of these worthies. Between ourselves

WHERE MEN ARE MEN AND WOMEN OBEY ORDERS

I don't mind admitting that I should like to go in and tie hard knots in all the clothing, curtains and bed coverings and thus get partial satisfaction for the many hours of misery I spent trying to untangle the arithmetical net in which they figured so prominently.

"However, since this highly commendable program is entirely out of the question, let us enter the home of John Doe and see what we can see. We find John in the counting room, counting out his money which is another way of saying that he is out in the kitchen, spitting in the coal scuttle and gloomily reflecting how much further ahead of the game he would have been if he had remained single. According to the nursery rhyme we should find Mrs. John in the pantry eating bread and honey. As a matter of cold, sordid fact we probably shall find her half in and half out of the icebox lunching lightly on a cold potato and the remains of a salt herring. If conditions were the same as they were in the good old days we should find the maid in the garden, hanging out the clothes and if we were lucky we might catch a glimpse of the wicked magpie—or was it a black bird—waiting for a chance to snip off her nose. *If* is a crooked letter, therefore we see none of these things. The maid is not in the garden for the simple reason that she is at the *Alhambra* breathlessly following her favorite hero while he upholds virtue with one hand and with the other knocks the packing out of vice with right good will. Incidentally there is no garden. The Does send their clothes to the Elite laundry which 'collects on Mon., Wed. and Fri., and delivers on Tues., Thurs., and Sat., Lowest Rates in Town.'

WHERE CONDITIONS APPARENTLY ARE NOT SO GOOD

"For the purpose of this argument we shall assume that John Doe Jr., and several of his slick hair associates are shooting craps on the dining room table or otherwise enjoying themselves innocently after the approved manner of the up and coming generation. Araminta Doe and her sister, Geraldine, are in the parlor practicing acrobatics which they confidently think will commend them to the attention of one Mr. Ziegfeld. They are aided and abetted in this truly laudable, but hopeless ambition by two able bodied young cubs, too weak to work, but quite capable of tootling a saxophone hours without end while in the most extraordinary positions.

"Here, if we are to believe the usual description found in papers, magazines and books of great circulation, here is the typical American family at home. John Doe himself surrounded by the members of his family, his lares and penates, in his own house—so long as he pays the rent. John Doe—at ease!

"Let us project ourselves into this quiet scene and subject the inmates to the imaginary test which we have tried successfully in the South sea island home.

"John shouts: 'Pig!' What is the result? Every person in hearing reacts to the shouted word in some manner, but certainly none takes it as a command to go forth and capture a squealer. His wife is highly offended at what she considers an entirely uncalled for reference to her exploration in the icebox. If she is a lady of spirit and has kept up with the times she will show her disapproval by pinking John here and there with the ice pick. If she is a graduate of the old school which taught that ladies under no circumstances should touch, much less, utilize, a lethal weapon, she envelops him in a flood of words that sting like scorpions and cover his spirit with large size bruises, welts and blisters.

"John Jr., hears the shout, but as a result of many years' training, he pays no attention. In a sub-conscious way he has an impression that he is wanted for something, but he is prepared with several alibis in the event that his suspicion is correct. He will maintain stoutly that (*a*) he did not hear any person calling him (*b*) he heard the first call, but naturally assumed that it was intended for some person, any person, other than him. He an' his fr'en's wus jis' min'in their own business an' not botherin' nobody. Righteously indignant he wonders why some other people he could name if he wanted to, cannot do the same thing. If both these alibis fail he still has a third (*c*) 'Pig? pig?' he will repeat in the tone of one who hears a peculiar foreign word for the first time 'jis' wot do ya mean, pig?'

"Araminta and Geraldine pay no attention to the shout of 'Pig' that goes reverberating through the old ancestral halls and from one room to another. This is due to the high state of perfection to which they have developed their faculty of concentration. To some extent also it is due to the boiler shop atmosphere of sound produced by the two saxophone blowing satelites or stalactites or whatever you call those drippy things, always hanging around, with no visible means of support and of no earthly use to themselves or to others. From the foregoing it is apparent that John Doe will have to change his tactics if he expects to secure any service. The single word 'pig' is not enough to ring the bell. Let us see to what extent a few additional words will help him out. Let him shout 'Bring me a pig' and see what happens. Without the slightest hesitation and without any specific knowledge of the object in question, Mrs. John tells him to get it himself, he is no cripple. Goodness knows she has enough work of her own to attend, without running his errands. What does he want another pig for anyway? One is plenty and to spare in any house.

"Araminta and Geraldine and the boy friends cannot spare any time from the practice of their art to run any silly errands. One brilliant young stalagmite can't see why the old man doesn't call up whatever blind pig he has in mind and have one sent out. Imposition, that's what it is, imposition, expecting any person to go and get it for him. Let him shout!

"John Doe Jr., as I explained some time back, is willing to jump into the breach to save the day and so forth, but first as I also mentioned he wants to know what kind of a pig is required."

"He is too fussy and particular," Bill interrupted at this point. "All he has to do is to dash down to the market and get a young pig, then

drop into a foundry yard and pick up a hunk of pig iron. Upon his return to the old homestead he can present the young porker to John Sr. If John Sr. protests that he did not order such an article, the boy can produce the iron pig and accidently drop it on the old gent's toe as a hint to moderate his wants in the future, or else describe them a little more specifically."

"Up to a short time ago," I said, "I shared your opinion on the subject of pigs, but the other day I had to hunt for a word in the dictionary. During the search I stumbled over this word 'pig' and was astonished to find that with its natural roots, branches and other appendages, it covered nearly a page. Listen for a minute. Origin of the word is uncertain. Formerly it was applied as the name of an earthenware vessel, a jar, pitcher or pot or even a cinerary urn. In some parts of the British isles the name still is applied to a small vessel of tin or wood. In early days the word was spelled pigge and Mr. Webster invites his readers to compare this spelling with a somewhat similar word in Dutch and Low German. The name is applied to a young swine, also to a swine of any age, wild or domestic. A quotation from the late Mr. Chaucer refers to 'Two pigges in a poke.' Ornaments and drinking vessels were made in the form of swine and were known as pigs. Among the humorous lads a piece of pork sometimes was referred to as 'a bit o' pig.' A greedy, gluttonous or filthy animal or person was and is known as a pig.

"At one time pig was a slang expression for a sixpence or for a policeman. The printing fraternity playfully referred to the pressmen by the same friendly title.

"Webster also is familiar with the sense in which the word generally is used. He says that a pig is (*a*) an open sand casting of metal, especially of iron or lead, run directly from the smelting furnace. Sometimes it is called an ingot or a mine pig. (*b*) Any of the molds or channels in the pig bed. (*c*) Collectively, pig iron, pig lead or the like.

"You probably will be surprised to learn that a parcel of hemp fiber weighing about 2½ pounds is known as a pig. I am not familiar with the salt mining industry and therefore cannot explain why a block of rock salt should be called a pig. The same is true of a small cushion used in knitting. Up in the timber country where men are men and words are made to fit the occasion, a dog boat is known as a pig.

"Ever since Chaucer's time, and perhaps before that time, the term 'a pig in a poke' has been employed to designate an article that has not been exposed to view in a buying or selling transaction and therefore is of unknown value or quality. Finally, we have pigs in blankets. Contrary to your natural expectation this does not mean a grunting, scrofulous, unclean creature wrapped in an eider down quilt. Not at all. The term is applied to oysters wrapped in thin slices of bacon, fastened with skewers and fried."

THE HORN OF THE HUNTER NEEDS REFILLING

"Is that all your old friend Webster has to say on the subject of pigs?" Bill asked.

"Not quite," I said. "He throws a little more light on the subject under such headings as pigging, pigged, piggery and pig sties dealing with (*a*) the reproduction of the species and (*b*) in a more or less figurative manner with those who huddle, lie together or live like pigs in one bed. Hunting the wild boar, in the event your curiosity is aroused on the subject, also is known as 'pigging.' "

"I don't know anything about hunting the wild boar," Bill said. "Up to the present he has not attained to the dignity of a game animal in this country.

"You can't go pigging in the city. All the pigs are blind and enjoy close police protection. No person is allowed to touch 'em. They are extremely shy and retiring and carry on most of their activities after dark. Their motto is *Caveat emptor*. That is Latin, not hog latin either, for 'Let the buyer beware!'

"Webster included practically everything in that long list, but I don't remember hearing any reference to a pig breaker. That is a fairly necessary piece of equipment around a gray iron foundry. I was reminded of this fact the other day by an inquiry from a man who asked me if I knew of any good, suitable rig for breaking castings and heavy pig iron for use in a 36-inch cupola. He claimed that attempt to break the sows that arrive with the cars of pig iron causes more men to quit than any other feature connected with the operation of his plant. The net result is that he has quite an accumulation of heavy pigs and heavy pieces of scrap that have been placed carefully to one side over a period of 15 years. Under present conditions the iron cannot be used and therefore represents a dead loss. With one or two exceptions the universal method for breaking pig iron and heavy scrap in the foundry yard is with the device known in the foundry as a drop ball and in the steel mills as a skull cracker. The application of the device varies in accordance with the general features of the plant, but the essential feature is that a cast iron or steel ball is lifted to a suitable height and then tripped so that it falls on the scrap.

"The usual method, particularly in smaller plants is to erect a three-leg derrick with a block suspended from the apex. One end of the rope from the block terminates in a hook for attaching to the ball. The other end is taken through a snatch-block anchored to a *deadman* or to the foot of one of the derrick legs, and thence to the drum of a hoisting winch operated by gas, steam, air or electricity.

"It is not necessary to melt the heavy pieces separately on the last charge and run the iron into smaller pigs for future use. That is a wasteful and obsolete practice. One or two of the heavy pieces safely may be placed on each of the regular charges. In fact any piece of iron that will go into the cupola can be melted. A little extra coke will be required on some of the larger pieces, but in many cases the cost of a few forkfuls of coke is less than that involved in trying to break the pig or scrap into small pieces."

QUERIES ON FOUNDRY PRACTICE

Suggested Solutions for Common and Unique Shop Problems

Too Much Clay Cause of Pitted Castings

QUERY

We are forwarding for your inspection a small piece of our stoveplate, also a sample of sand. You will note the surface of the casting is pitted and that the sand contains a great many little round pellets. These pellets are not shot iron or pebbles in the sand. They may be crushed readily to the same fineness as the remainder of the sand. This sand formation is not apparent in our new sand, but only appears after the sand has been in use for some time. Naturally we associate these pellets with the pitted surface of the castings, but we are at loss to account for the peculiar action of the sand. We shall appreciate your opinion on three specific points: Are we right in assuming that the pellets cause the pits, what is the cause of the pellets, how can we prevent their formation?

ANSWER

From the fact that a small area of the casting showed where some of the blacking *washed* in front of the iron we hesitate to lay all the blame for the pitted castings on the sand. Sometimes a combination of conditions and sometimes a single unsuspected factor are responsible for pitted surface. For example under certain conditions a blacking will rise up on the face of a mold like gooseflesh and the result is a pitted surface on the casting. Stray pellets of clay in the facing sand will produce the same result. We mention these points to indicate that a solution of your problem may take you over a longer trail than you anticipate. However, without a first hand knowledge of your operating conditions and materials and basing our opinion solely on the information submitted we are inclined to the opinion that the small pellets in the sand are responsible for the pitted surface on the casting.

Too much clay in the sand is the cause of the pellets and one of three courses is open to you. You may order a new supply of sand containing a lower percentage of bonding element and use it exclusively close to the patterns. You may grind all the present sand you require for facing. You may sieve a pile of sand first upon the floor where all the pellets will roll to the bottom, and then sand from the same pile on to the pattern. This double treatment will remove practically all the pellets from the immediate vicinity of the pattern. Owing to economic conditions the second course is the most logical if you intend to continue using your present kind of sand.

Builds Fire in Ladle To Insure Hot Iron

QUERY

I have a stack 24 inches diameter quite suitable for melting iron for small castings. I now have a planer bed to make, 9 feet in length, ½-inch thickness of metal and estimated to weigh 1000 pounds. I have a ladle that will hold 1400 pounds. The charges will be made up of mowing machine scrap with the necessary additions of ferrosilicon and ferromanganese. Will I have any trouble collecting the necessary amunt of hot metal in the ladle? Should I add a small amount of lead, tin or aluminum?

ANSWER

A 24-inch cupola will melt about 4000 pounds of iron per hour which means that you should fill your ladle in about 20 minutes. With the tuyeres 10 inches above the bottom the cupola will hold enough iron to fill the ladle in two good taps. You can watch through a peep hole in one of the tuyeres and tap the iron before it rises too high. Assuming that your cupola practice is all that it should be and that the metal comes white hot from the spout, you do not need to add either tin, lead or aluminum to the iron in the ladle. The only precaution necessary is to provide a thoroughly dry and hot ladle. This may be accomplished by building a wood fire in it or—if one is available—by using an oil torch. The fire is kept going until the metal is ready and if wood is used the hot coals and charcoal are allowed to remain in the ladle while the metal is running from the spout. This material will form a cover and help retain the heat from one tap to the following tap. It is skimmed off before the metal is poured in the mold. The cupola melts a little slower than usual at the beginning of the heat. Therefore, it is advisable to take away one or two small ladles of metal first before placing your 1400-pound ladle under the spout.

Plate for Split Pinion

QUERY

We have a pinion to make which has to be split with iron plates. We will appreciate your advice on how to coat these plates to prevent the cast iron from sticking to them.

ANSWER

You do not state whether the opinion is large or small, wide or narrow face, poured from the top or the bottom, or, whether the casting is to be cast to size or requires to be machined to a fit after the splitting plates are removed. All these factors exert a direct bearing on a problem of this kind and must be submitted before a specific answer can be given.

For small or medium weight pinions, or other split wheels, a thick coating of graphite will protect the plates from fusing to the molten iron. In some cases the plate either is dipped in oil or painted with oil and then sprinkled with graphite. In other cases the graphite is dampened with oil and rubbed on by hand. A more satisfactory method is to coat the plate with wet blacking in the usual manner and dry it in the core oven. One precaution that must be observed before a coating of any kind is applied is to see that the surface of the plate is clean. The least deposit of rust or scale will cause the molten iron to fly when it comes into contact. One method of cleaning a plate is to place it in the fire until it becomes red hot. Any scale adhering then may be scraped off. The other methods are to grind the surface of the plate on a suitable wheel or use a sandblast to obtain a clean surface.

The best method for splitting a wheel, particularly a large wheel, is to employ two plates face to face. They are left uncoated, or in some cases coated on one side with water glass (sodium silicate) so that they will be sure to fuse to the casting, but not to each other. Several holes are drilled or punched through each plate and afterward countersunk on the face side to assist in anchoring the plate to the face of the casting. The holes in each plate are laid out in a manner that will prevent any two holes in the two plates from coinciding. In this style of split the joint is not machined later.

LARGE CASTING

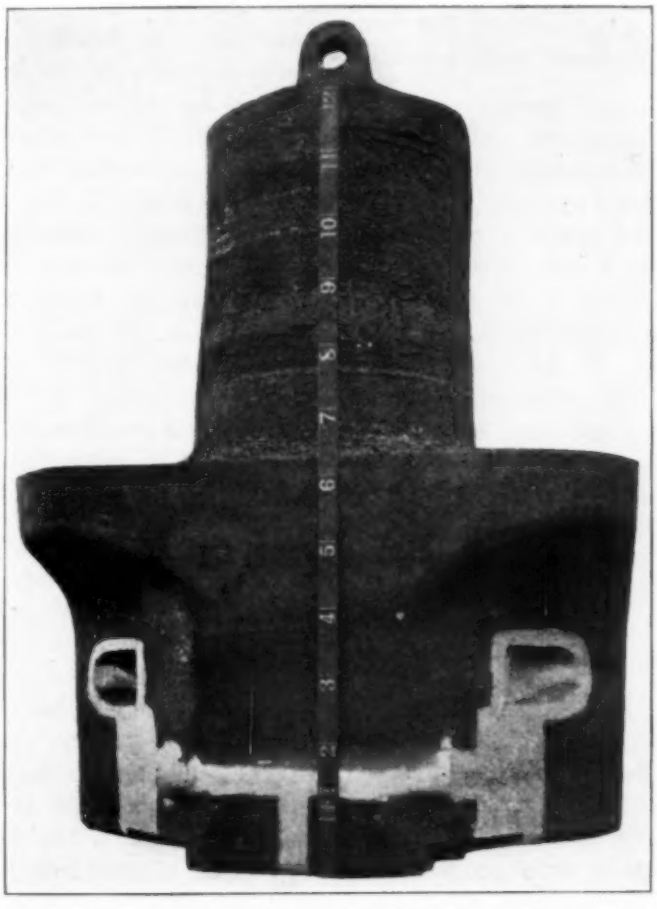
Is Made in

English Foundry

CAMMELL LAIRD & CO., Ltd., Sheffield, England, recently completed one of the largest steel castings ever made by the foundry industry. The casting was an anvil block for a friction drop hammer designed for use with a 5-ton ram. The casting is unusual not only for its size but also because of its design. It was made for B. & S. Massey Ltd., Manchester, England, makers of forging hammers, for a machine for the Firth-Derihon Stampings, Ltd., Sheffield road, Carbrook, Sheffield, England.This casting was made of mild steel whose analysis was as follows: Carbon 0.251, silicon 0.207, manganese 0.881, sulphur 0.041, phosphorus 0.040. A forged plate of armour steel was dovetailed into the top surface to allow for the wear caused by the die block. Some idea of the size of the casting may be obtained from the accompanying illustration. As indicated by the scale, the casting and the head was over 12 feet high and the block measured 9½ feet at its greatest width. The head alone is about 6 feet high and 4 feet in diameter. The total weight of the piece was 142 tons. The head weighed 30½ tons and the machined weight of the casting was over 95 tons. Particular care was taken in making this casting because the loss of such a piece through defects would entail a large loss to the company. The process followed in making the piece was as follows: An exact wooden model was constructed and this was examined for all the possibilities of casting, handling and machining. As can be seen from the illustration the block was cast with the working face down. The block was cast in a dry sand mold set in the floor so that the bottom of the block was on a level of the floor. The casting was cleaned in the usual manner. Two 70-ton open-hearth furnaces were used for the charge.

A lifting eye like that used for armour plate and other large sized ingots, was cast in the feeder head to facilitate the handling of the casting and was left in place until the whole working face was machined.

To avoid using small cores in such a large casting, the block was cast solid and all holes were machined. No sign of shrinkage cavities or other defects were discovered when the casting was machined. The amount of machine work necessary can be gaged by the fact that over 16 tons of metal had to be removed. The head was not removed until the face of the casting had been machined. This casting was so successful that Cammell Laird & Co., Ltd., has received orders for other large blocks.



TWO OPEN-HEARTH FURNACES OF 70 TONS CAPACITY WERE NECESSARY TO FURNISH THE METAL FOR THIS BLOCK

Dr. Edward Weston, internationally known electrochemist and inventor of the Weston cell has established the Edward Weston fellowship with the American Electrochemical society. The candidate will be elected by the society and the selection will be based on the capacity of the applicants for research in electrochemistry or its application. The award will be made without regard to sex, citizenship, race or residence. The successful candidate may carry out his research at any university or institute approved by the society. The award is approximately $1000. The date for the first award has not been set but probably will be in the fall of 1929. Those who are interested in the fellowship should send their application to the office of the American Electrochemical society, Columbia university, New York, Colin G. Fink, secretary.

The Shakeout

DAN M. AVEY, Editor
PAT DWYER, Engineering Editor
EDWIN BREMER, Metallurgical Editor
FRANK G. STEINEBACH, Managing Editor
CHARLES VICKERS, Nonferrous Editor
NORMAN F. HINDLE, Assistant Editor

¶ Brains Pay!

INTELLIGENT leadership in a foundry is an intangible asset that cannot be measured directly in dollars and cents. However, its presence is indicated clearly when the books are balanced at the end of the year. Profit is the result of intelligent management while loss shows the lack of it. The type of management that produces results and profit hardly lies in the hands of one individual. It means a co-operative effort of the officials of the firm, the sales department and the heads of the various foundry departments. The skeptic will say, "Yes, that is fine for the large foundry, but how about the little fellow?" —A reasonable question to be sure, but it may be pointed out that co-operation in the smaller foundry should be easier than in the larger because in many instances the officials of the firm also are the sales force and department heads.

ONE of the most important requirements of intelligent management is never to accept work which does not promise a reasonable profit. This in turn necessitates an exact knowledge of every possible cost factor that may enter into the production of castings. Reasonable accuracy in cost accounting does not require a flock of statisticians as many are inclined to think. It only means a careful tabulation of figures obtained from the melting, molding, coremaking and other departments. Once these are established for a variety of casting types, definite prices including a reasonable profit may be quoted on castings within the capacity of the foundry.

Intelligent management is not an ethereal substance, nor is it that to which a great many apply the term *Good Luck*. While as previously stated it is intangible, it is something that readily can be recognized.

JUST one illustration will prove the point: A steel foundry in a midwestern city was directed by a manager who was familiar with all the details entering into the production of castings. He accepted no work unless it was profitable to the firm. Consequently, the business went merrily on its way showing a nice profit at the end of each year. However, the manager was not content to work for someone else so he decided to paddle his own canoe. He went to a banker and laid his cards on the table. The banker realizing that not only did the foundry manager know his business, but also possessed the faculty of intelligent leadership, played card for card and loaned him $80,000. With the money at hand, the manager selected a site for his foundry, purchased an electric furnace and other foundry equipment, and then went out for business. To make a long story short, he paid back the loan in 4 years and now possesses a thriving business.

Intelligent leadership does pay—Think it over!

¶ Castings Consciousness

THE Cast Pipe Research association, an organization of leading pipe founders formed to further proper use of cast-iron pipe, recently has offered an answer to an important question in the minds of the American public. In an advertisement appearing in a national weekly, the association points to the discomforts caused to motorists through irregularities in pavement which result from covering trenches containing underground piping. Blame for this condition is laid at the door of the property owner who fails to demand a modern system of laying underground pipes. Attention is directed to a booklet entitled *The Two-Main System of Underground Piping*, which is being distributed free.

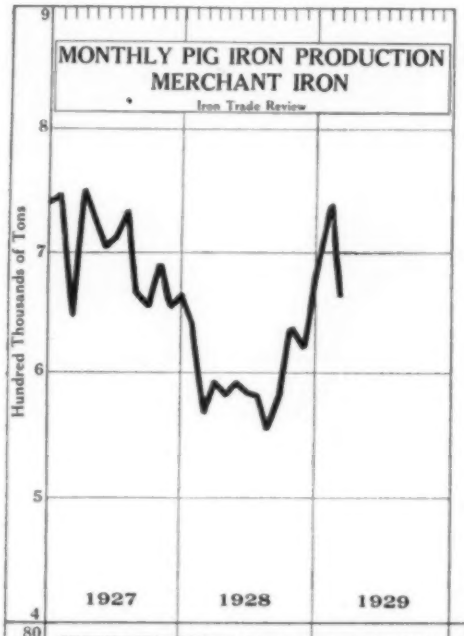
WHILE every foundryman is interested directly in this modern system of laying gas and water pipe when considered from the standpoint of the property owner, a still greater significance may be attached to this advertisement. It carries the message of a cast iron product to several million people, building good will for the products of the foundry. Blazoned across the bottom of the full page in large type and capital letters are the words CAST IRON PIPE. Such advertisements will make the American public appreciate the value of cast-iron pipe, and incidently should create a cast iron consciousness. The benefit accrues indirectly to every gray iron foundry.

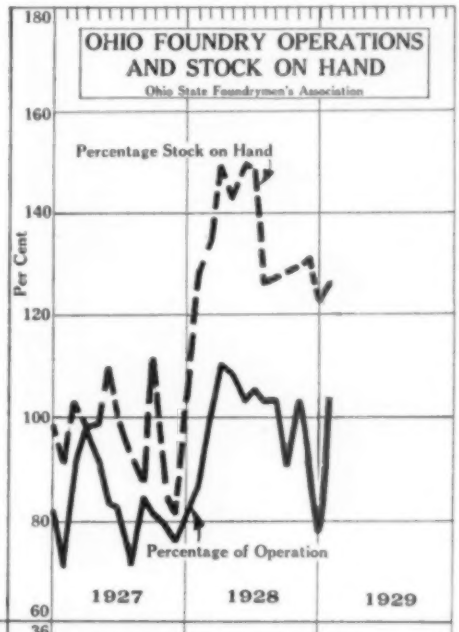
Trade Trends in Tabloid

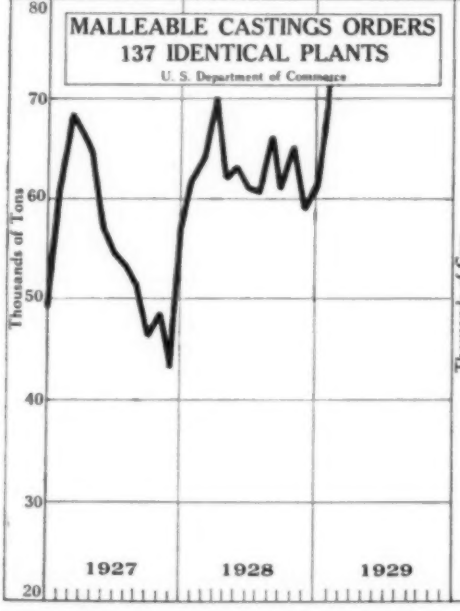
FOUNDRY business continues good with the entry of the spring season. Demand for castings is supported by the automobile makers' activity, a continuation of building construction, improved machine tool demand, farm equipment manufacturing activity and the requirements of contributory industries. Malleable castings orders for January, according to the department of commerce totaled 77,091 tons for the 137 plants reporting. This is 77.5 per cent of the rated capacity of these plants. The Gray Iron Institute Inc., of which A. J. Tuscany is manager, reports the ratio of production to normal melt as 118.7 per cent for 77 of its member foundries. The normal melt figure is the average of the past three calendar years. Steel castings orders for January were 64 per cent of capacity. The rate of pig iron production during February, according to *Iron Trade Review*, 114,833 tons per day was the highest February on record and second only to March, 1925, when its average daily output of 115,207 tons per day. Merchant iron production in February totaled 659,785 tons, compared with 744,448 tons for January. Average New York prices for nonferrous metals during February, according to *Daily Metal Trade*, follow: Casting copper, 17.735c; electrolytic copper, 19.971c; Straits tin, 49.357c; lead, 6.857c; antimony, 9.535c; aluminum, 23.90c. Zinc averaged 6.350c, E. St. Louis, Ill.

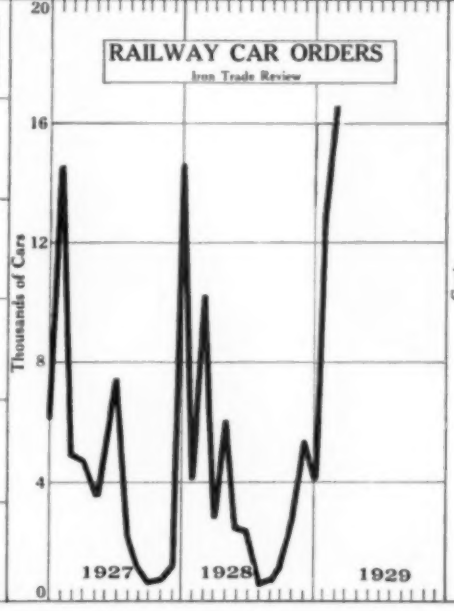
RAW MATERIAL PRICES
March 7, 1929

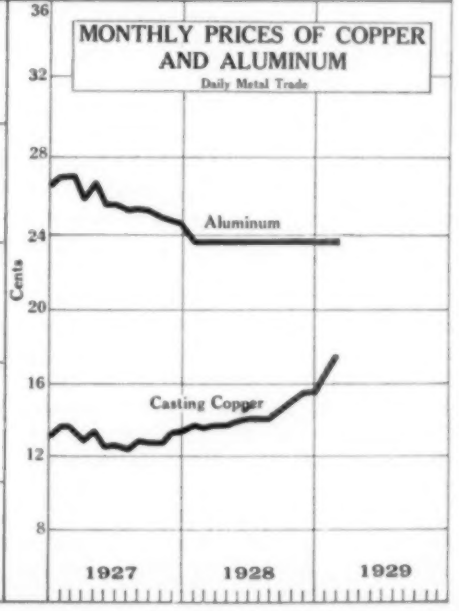
Iron	
No. 2 foundry, Valley	$17.50
No. 2 southern, Birmingham	16.50 to 17.00
No. 2 foundry, Chicago	20.00
No. 2 foundry, Philadelphia	21.25 to 21.75
No. 2 foundry, Buffalo	18.50
Basic, valley	17.50
Basic, Buffalo	17.50
Malleable, Chicago	20.00
Malleable, Buffalo	19.00
Coke	
Connellsville foundry coke	$3.75 to 4.85
Wise county foundry coke	4.25 to 5.00
Scrap	
Heavy melting steel, Valley	$17.50 to 18.00
Heavy melting steel, Pitts.	18.25 to 18.50
Heavy melting steel, Chicago	15.50 to 16.00
Stove plate, Buffalo	14.75 to 15.00
Stove plate, Chicago	12.75 to 13.25
No. 1 cast, New York	13.00 to 13.50
No. 1 cast, Chicago	16.00 to 16.50
No. 1 cast, Philadelphia	16.00 to 17.00
No. 1 cast, Pittsburgh	15.00 to 15.50
No. 1 cast, Birmingham	14.50 to 15.00
Car wheels, iron, Pittsburgh	16.00
Car wheels, iron, Chicago	14.50 to 15.00
Railroad malleable, Chicago	18.50 to 19.00
Agricultural mal., Chicago	15.50 to 16.00
Malleable, Buffalo	17.50 to 18.50
Nonferrous Metals	Cents per pound
Casting, copper, refinery	19.25
Electro, copper, producers	19.62½
Straits tin	48.62½
Lead, New York	9.25
Antimony, New York	9.25
Nickel, electro	35.00
Aluminum, No. 12, producers	23.00
Aluminum, No. 12, remelt	16.50 to 17.00
Zinc, East St. Louis, Ill.	6.35











Comings and Goings of Foundrymen

Men of the Industry, Whose Activities Are Making Foundry History

COL. ROBERT PATTERSON LAMONT, recently appointed secretary of commerce by President Hoover, has been president of American Steel Foundries since 1912, and was first vice president from 1905 to 1912. Mr. Hoover and Mr.

COL. ROBERT P. LAMONT

Lamont have been friends for some years, and while the former was secretary of commerce the two met on various occasions in pursuit of allied interests. During the time Mr. Lamont served the United States chamber of commerce as a member of its commission for the study of economic and trade conditions in Europe, and also during the reconstruction and relief work following the Mississippi river and other flood disasters in the past several years, the two were associated. Mr. Lamont, in addition to his official capacity with American Steel Foundries, is engaged in various other business and industrial activites. He started his career at Chicago about the time of the World's fair in 1893, doing engineering work at the exposition in 1891 and 1892, just preceding the fair. Mr. Lamont went to Chicago from the University of Michigan, after receiving his degree in engineering. His first business connection in Chicago was that of secretary and engineer of Schailer & Schinglan, contractors. Later he became first vice president of the Simplex Railway Appliance Co., in which position he remained eight years until he became first vice president of American Steel Foundries. He now is associated with nearly a score of other industrial and civic organizations. He is chairman of the Griffin Wheel Co., director of the First National bank and Morris plan bank, Montgomery Ward & Co., Armour & Co., the Illinois Bell Telephone Co., International Harvester Co., Chicago, Globe Steel Tubes Co., Milwaukee, and American Radiator Co., Dodge Bros., and others. He also is president of the General Steel Casting Corp., recently formed at Eddystone, Pa. During the World war he was commissioned a colonel and became chief of the procurement division, ordnance department of the army. For his services Colonel Lamont was awarded a distinguished service medal by congress.

E. C. Howell, Dayton, O., has been appointed general manager of the Dayton Malleable Iron Co., at Canton, O.

Lamar S. Peregoy, vice president and secretary, Sivyer Steel Casting Co., Milwaukee, has been appointed general manager of the company. Mr. Peregoy has been connected with the Sivyer Steel Casting Co. since its inception in various capacities. He also is a director of the Federal Malleable Co., Milwaukee, an affiliated company.

LAMAR S. PEREGOY

William H. Hoppenjans, recently elected president of the Tri-State Foundrymen's association, Cincinnati, is president of the Star Foundry Co., Covington, Ky. Mr. Hoppenjans was born in Covington in 1886 and graduated from high school in 1900. After attending the Bartlett Commercial college, Cincinnati, he entered the employ of the Licking Rolling Mill Co., Covington. In 1904 he became connected with the Star Foundry Co. as office assistant and in 1913 he was made a director and secretary of the company. He was elected president on Jan. 1, 1927. Mr. Hoppenjans is president of the Kenton Development Co.; a director of the Citizens National bank, and the Kentucky League of Local Building associations; and a past director of the Rotary club of Covington, Industrial club, Kentucky Society for Crippled Children, Boy Scouts, Associated Industries of Kentucky, and the state chamber of commerce. He also has been an officer in several of the organizations named. He now is a member of a permanent committee for the stabilization of

WILLIAM H. HOPPENJANS

employment in Hamilton county, Ohio, and Kenton and Campbell counties, of Kentucky.

Frank Hudson, chief metallurgist, Glenfield & Kennedy Ltd., Kilmarnock, Scotland, has been chosen by the Institute of British Foundrymen to present the annual exchange paper before the 1929 convention of the American Foundrymen's association, which will be held at the Stevens hotel, Chicago, April 8 to 11. This paper is to be one of a series initiated in 1921 on agreement between the British and American associations and in which the French and Belgian foundry associations later entered.

FRANK HUDSON

Mr. Hudson was educated at Rutherford college, Newcastle-on-Tyne, England, and holds a first-class certificate in iron and steel manufacture from city and guilds of London institute. He served an apprenticeship as a practical metallurgist with Armstrong-Whitworth & Co., under H. H. Ashdown and Oliver Smalley on armament and general engineering work. Mr. Hudson's first executive position was melting manager at the Close Works Iron Foundry of that company. He made a special study of cupola problems and the production of refined iron and high duty cast iron for diesel engine and locomotive work while holding that position. In 1924 Mr. Hudson was appointed metallurgist to the government of Tibet to supervise the installation and manufacture of electric steel at Lhassa, but was advised at the last minute by the British government not to go, due to political unrest. From 1925 to 1927, Mr. Hudson resided in Canada and the United States and was associated with the American Brake Shoe & Foundry Co., Chicago; Warren Foundry & Pipe Co., Phillipsburg, N. J., as metallurgist, and with the Wyoming Shovel Works, Wyoming, Pa., as assistant superintendent. He is a member of the American Foundrymen's association; American Society for Steel Treating, and the Institute of British Foundrymen, and has contributed several papers on foundry topics, being awarded a diploma by the Institute of British Foundrymen in 1928 for a paper on Scottish molding sands.

Isaac J. Pritchard has been appointed acting superintendent of the Utica, N. Y., plant of the Richardson & Boynton Co., New York.

John Duffy and Patrick Kiloran, melters in No. 2 shop, Indiana Harbor plant, American Steel Foundries, have retired on pensions.

Martin A. Fladoes, sales manager, Sivyer Steel Casting Co., Milwaukee, has been elected a director of the company. He has been with the Sivyer company in the engineering department for about 8 years.

A. A. Grubb, formerly with the Ohio Brass Co., Mansfield, O., now is engaged in research work at the California Institute of Technology. He is doing work on colloids and expects to extend the investigation to particle sizes over the whole range found in clays.

Tri-State Elects

The Tri-State Foundrymen's association, Cincinnati, recently elected the following officers: President, William Hoppenjanz, Star Foundry Co., Covington, Ky.; vice president, A. G. Wessling, Wessling Bros. Foundry Co., Cincinnati; treasurer, Charles B. Erhart, Chris Erhart Foundry Co., Cincinnati; secretary, George W. Piehl, Wessling Bros. Foundry Co., Cincinnati. The association meets the second Thursday of each month at the Cincinnati club, Eighth and Race streets.

Foundrymen Meet

The Gray Iron institute recently held group meetings for the foundrymen in various districts as follows: Fort Pitt hotel, Pittsburgh, Feb. 28; Worcester Council of Foundrymen, Worcester chamber of commerce, Worcester, Mass., March 11; Connecticut Foundrymen's association, Meriden, Conn., March 12; and New England Foundrymen's association, Boston, March 13. These meetings were held to acquaint the foundrymen of the various sections with the phases of the work of the Gray Iron institute.

Standart Made President of Equipment Group

At the annual meeting of the Foundry Equipment Manufacturers association held at the Cleveland Hotel, Cleveland, March 5, Henry W. Standart, president of the Northern Engineering Works, Detroit, was unanimously elected president for the ensuing year; Arthur F. Jensen, president, Hanna Engineering Works, Chicago, was elected vice president, and H. Cole Estep, vice president, the Penton Publishing Co. was re-elected secretary-treasurer.

Two new directors also were named,

HENRY W. STANDART

M. C. Sammons, secretary, Wadsworth Core Machine & Equipment Co., Akron, O., for the year 1929, and J. P. Jones, manager of sales, machinery manufacturers section, General Electric Co., Schenectady, N. Y., for the years 1929-1931.

L. P. Robinson, sales manager, Werner G. Smith Co., Cleveland, gave an address, entitled "What Is Becoming of the Foundryman's Dollar?" C. J. Stark, president, the Penton Publishing Co., spoke on the business outlook.

The reports of the members on business conditions were exceedingly encouraging. The average of sales for the first two months this year was 90 per cent in excess of the corresponding period in 1928.

The fifth regular meeting of the Wisconsin Gray Iron group was held at the Schroeder hotel, March 6. Tom Stewart, general superintendent, Case Co., Racine, Wis., was the principal speaker of the evening.

Elects New Officers

C. A. Barnett has been elected president and O. D. Conover has been made vice president of the Foundry Equipment Co., Cleveland. Mr. Barnett has been associated with the Foundry Equipment Co. since July, 1916 and has been successively treasurer and vice president and general manager. Following his graduation from the University of Michigan in 1914 and prior to his association with the Foundry Equipment Co., he was employed by the National Carbon Co., Cleveland, specializing in electric furnace work. Mr. Conover has been

O. D. CONOVER

employed by the Austin Co., industrial engineers and builders, for the past 10 years as assistant chief engineer. He has had considerable experience in foundry engineering and construction not only with the Austin Co. but also with the T. W. Price Engineering Co., New York, where he served in the capacity of chief engineer and vice president. Mr. Conover also has been production manager of the Ludlum Electric Furnace Corp. and chief engineer of the Bergen Point Iron Works.

Lectures on Corrosion

Approximately 200 members and guests of the Cleveland Engineering society, and local branches of the American Society for Steel Treating, American Society of Mechanical Engineers and the American Institute of Mining and Metallurgical Engineers, attended a lecture presented by Dr. Ulick R. Evans, Cambridge university, Cambridge, England, on corrosion of metals at Cleveland, March 5. Dr. Evans pointed out that thin adherent films of oxides prevented corrosion as long as the films were intact. However, it is difficult to obtain continuous films that will withstand corrosive action. Corrosion may be prevented in some cases by use of inhibitors such as sodium or potassium chromate or sodium phosphate placed in the water or painted on. This does not work effectively in all cases, and other means of prevention must be used. Alloys steels and iron of the stainless type are quite effective, but do not withstand all corrosive media. Other methods used are deposition of another metal upon steel or iron, and painting. Deposition or electroplating metals such as nickel, zinc, lead and copper generally are excellent protective agents, provided the coat is thick enough and is not porous. Painting should be done on clean, dry surfaces, otherwise rusting will take place. Since the rust occupies a greater volume than the metal, the paint is raised from the surface and in time flakes off. A paint should be chosen that contains the least amount of oil that will form a firm, adherent coat of pigment. Flaky metallic paints such as aluminum and other bronzes give good results when applied properly.

Organizes Foundry Firm

David Baker Inc., engineers, consisting of David Baker Jr., Edward T. Child and Leonard C. Crewe, has purchased the Bate Foundry, Conshohocken, Pa., and have organized the Conshohocken Foundry Co. to operate it. It will be used as an experimental foundry for the solution of metallurgical problems and for the production of gray iron, nickel and other alloy castings for local consumption. It is being equipped with modern equipment. The melting equipment consists of cupolas and crucible furnaces. The use of an electric furnace is contemplated in the near future. L. C. Crewe is president of the new company, Frank A. Booth, formerly assistant superintendent for Ford & Kendig, is superintendent of the plant, and A. B. Fairbairn is in charge of sales.

To Inspect Foundry

The March meeting of the Detroit Foundrymen's association will be in the form of an inspection trip to the Detroit Gray Iron Foundry Co., Wright and Iron streets, Detroit. The meeting is scheduled for March 16.

To Revise Codes

Codes regulating the specific requirements in foundries and core rooms and the regulation for the employment of women in corerooms are being revised by a committee appointed by the Industrial commission of Ohio. This committee is representative of both employers and employes. The Ohio Foundries association has a committee of five who are working on this committee. Ralph West is chairman of the industrial commission's committee. The members of the association's committee are L. H. Wise, H. V. Dockray Brass

C. A. BARNETT

& Iron Co., Zanesville, O.; R. R. Simonton, Ensign Foundry Co., Toledo, O.; E. A. Leary, Cincinnati Steel Casting Co., Cincinnati; A. H. Kramer, Advance Foundry Co., Dayton, O., and W. W. Sherman, Electric Auto-Lite Co., Fostoria, O. Ohio foundrymen are requested to send suggestions for revision of the old code to Elmer F. Scott, secretary-manager, Ohio Foundries association Inc., 418 Penton building, Cleveland.

Melts Iron in the Cupola

(*Concluded from Page* 237)

a temperature of 100 to 150 degrees Cent. Starting from cold, the regenerator is said to reach a temperature of 400 to 500 degrees Cent. in 15 minutes. The makers claim that with this cupola the charge coke is reduced by 25 per cent and a consequent reduction in the sulphur content of the metal. It is stated that up to Oct. 1925, the arrangement has been fitted to about seventy cupolas in

German foundries. In England and the United States, this arrangement has been tried on several cupolas, and so far as the author's knowledge goes it has been abandoned.

A further recent attempt by the Griffin Wheel Co., Chicago, to provide hot blast has been described in THE FOUNDRY, Sept. 15, 1926, page 729. A similar saving of about 25 per cent in the fuel consumption is claimed. It is stated that out of 60 per cent of the gases of combustion passing up the stack in the ordinary way, 40 per cent is drawn off by the exhausting fan from a wind belt encircling the cupola about 2 feet below the charging door. Gases withdrawn by the fan naturally contain a little carbon monoxide. They are passed through a down pipe to a combustion chamber where the carbon monoxide is burned with the addition of secondary air. Sensible heat contained in the gases and heat resulting from combustion of the carbon monoxide is transferred to the blast by passing the hot gases through a chamber containing a battery of cast iron pipes. The blast passing through this chamber absorbs heat and is delivered to the cupola at a temperature of 300 degrees Cent. This arrangement applied to a 74-inch diameter cupola is stated to have been in successful operation on a production basis for about 2 years, melting from 20 to 21 tons per hour for 6-hour runs each working day.

In another ingenious design of hot blast cupola, illustrated in Fig. 97, the preheater is built around the cupola shell and is heated by the hot waste gases directed by the specially formed passages A_1 above the upper limit of the melting zone into the passages A_2 and thence by way of A_3 into the stack. The incoming aid is led through this preheater by way of W_2 and W_1 to the wind belt K.

Attempts to recover latent heat by the injection of secondary air to burn carbon monoxide inside the cupola are fairly familiar. Introduction of two rows of tuyeres by Jonathan Ireland probably was the first attempt. Ireland was followed at a later date by D. Y. Stewart, who introduced secondary air by auxiliary tuyeres at a series of different levels above the normal tuyere level. Probably this cupola was the origin of the standard Stewart rapid cupola which for a long time was equipped with only three rows of tuyeres. Change from five rows in the original Stewart cupola to three and later to two rows in the modern standard Stewart rapid cupola typifies a gradual change in opinion regarding the extra rows of tuyeres.

Considerable prominence has been given the original Stewart arrangement and later Greiner and Erf construction through revival of a similar construction recently under the title of the Poumay system. The Greiner construction has been illustrated previously. This new construction similar to that given by Kirk, Rhead and others, presents auxiliary tuyeres spirally disposed around the cupola stack. The cupola differs from Greiner's, illustrated in the British patent No. 6939/1885 in which additional tuyeres in three horizontal rows were fed by three ring mains connected to the main wind belt. This arrangement in many respects was similar to one which came under the writer's charge some years ago, and which is illustrated in Fig. 94.

Controls Pouring Temperature

AT A meeting of the London branch of the Institute of British Foundrymen held on Feb. 14 H. C. Dews gave a lecture on "Theory and Practice of Gun Metal Casting." Mr. Dews restricted his subject to the discussion of casting temperature, which he believed is the most important consideration for obtaining successful results. As the liquid metal cools down and becomes solidified, the contraction may be divided into three periods. There is a certain contraction during the time when the liquid cools down while remaining liquid. This is followed by a period during which the metal remains in a pasty state over a substantial interval of temperature. During this interval there is further contraction. Finally, the last period of contraction takes place when the metal is solidified completely.

The first period of contraction can be remedied by pouring additional metal into the mold while the metal is in the liquid state, and the third period of contraction is taken care of by the patternmaker. The second period of contraction is the most difficult to cope with and has to be taken care of by the founder. It is difficult to neutralize the contraction during the pasty state by adding liquid metal in the central part of the casting, because in this condition the casting begins to assume a dendritic structure, through which the metal has to flow, and herein lies the difficulty.

Gives Casting Temperature

Mr. Dews stated that the remedy was to cast at the maximum temperature, but this temperature depends on the composition of the gun metal and on the nature of the casting itself. Metallurgists who have studied specially the casting of gun metal do not agree on the most satisfactory casting temperature. Opinions vary from below 1100 degrees to above 1200 degrees Cent. However, every metallurgist who had studied the question considered 1160 degrees as being in the range of satisfactory temperatures. Mr. Dews suggested that, when starting to make a particular casting with a particular composition of gun metal, a temperature of 1160 degrees should be adopted at the beginning.

If the result is unsatisfactory, it then is necessary to cast at a higher or lower temperature, and the best guide to the procedure is to break the casting and examine the fracture. A sound casting should show a homogeneous mass of small crystals, and the edges and skin should be of a uniform bluish color. If the fracture presents cavities, it shows that the casting temperature was not correct, and with little experience it is possible to know whether the casting has been poured too hot or too cold.

In view of the importance of the casting temperature, it is necessary to have a means of measuring the temperature. Mr. Dews strongly advised the use of the thermoelectric couple, with bare wires. During the lecture the author showed a number of slides containing curves which illustrated the points he had raised, and also showed that the strength of the casting increases up to the point when the maximum casting temperature is reached.

Wesley Lambert, metallurgist, J. Stone & Co. Ltd., London, stated in the discussion, that he prefers to use a couple whose wires are protected by a sheath. Mr. Dews replied that in the case of gun metal, where the pots contained only a small quantity of liquid metal, he prefers bare wires, because the result is more immediate. The wires are protected partly by surrounding them with asbestos covered by some refractory material, so that the part which enters through the surface of the molten metal is pro-

tected, and only the extremities of the wires dipped inside the pot are exposed. When the right temperature nearly is approached, the couple is dipped into the bath for a few moments and taken out again. This is repeated until the correct temperature is registered.

Another point raised in the discussion by a speaker was that in casting two test bars with the same runner and from the same pot of metal, two test bars were obtained giving different results. Mr. Dews replied that this often happens when casting two test bars together, and that it is not confined to gun metal. This happens because one bar is filled before the other. When the metal has filled the first bar and runs round to the second, it is no longer at the same temperature as at the beginning of the cast. Good results are obtained by casting two test bars flat, using a heavy runner, and also uniting the two test bars at the other extremity by a riser of similar size to that of the runner. Under those circumstances both test bars are filled together and give more uniform results.

What the Foundries Are Doing

Reflecting the Activities of the Gray Iron, Malleable, Steel and Brass Shops

United Casting Co., 824 Wilson street, Los Angeles, has increased its capital to $150,000.

Stoody Co., Whittier, Calif., has discontinued the operation of its foundry department.

Chicago Foundry Co., 2028 North Major avenue, Chicago, has awarded a contract for a 2-story addition, 75 x 80 feet, to cost $8500.

Zanesville Malleable Co., Zanesville, O., has reopened its plant after a long suspension of operations.

Viking Pump Co., Cedar Falls, Iowa, is planning a merger with the Falls Foundry Co. and the Banner Brass Co., both of Cedar Falls.

Precision Machine & Foundry Co., Calgary, will start work in the spring on a foundry to cost $120,000. Equipment will be purchased.

Bryant Pattern Co., Shepard and Highland avenues, Chicago, has filed plans for a new factory, 80 x 90 feet, to cost $18,000.

California Malleable Castings Co., Los Angeles, has built an addition to increase its foundry floor and cleaning room capacity.

The Atlas Brass Foundry, 1901 Santa Fe avenue, Los Angeles, has purchased some ground adjoining its property to be used for extension.

Acme Aluminum Foundry Co., 814 West Seventy-fifth street, Chicago, has increased its capital from $15,000 to $100,000.

Waukegan Foundry Co., North Chicago, Ill., Twenty-second street and Commonwealth avenue, suffered damages by fire recently.

National Casting Co., Marietta, O., suffered damages to its plant, patterns and machinery in a recent fire.

East St. Louis Casting Co., East St. Louis, Ill., announces plans for new foundry additions costing $200,000. Ralph M. Hill is president.

Scott & Williams Inc., manufacturers of knitting machines will build a new plant which will constitute its third unit.

Verona, Pa. plant of the American Steel Foundries, which has been idle for some time, will be put into operation as soon as possible according to C. D. Carey, works manager.

Michigan Smelting & Refining Co., Detroit, has awarded the contract for remodeling its foundry to the Krieghoff Co., Detroit. C. W. Brandt is the architect.

Kohler Co., Kohler, Wis., has taken over the foundry portion of the Bassik Co., Passiac avenue, Newark, N. J., and will remodel it for an eastern factory and distributing plant.

S. & S. Die Casting Co., Providence, R. I., has purchased the plant formerly owned by the William H. Hamblyn Co., Cranston, R. I., and will equip it for manufacturing.

Wessling Bros. Foundry Co., Cincinnati, has purchased the plant of the American Foundry & Machine Co., Hamilton, O. and plans to remove its major operations to the latter city.

Clem Duncan Foundry has succeeded the Master Carburetor Co., 3020 South Main street, Los Angeles. It will make brass, bronze and aluminum castings.

West Coast Foundry, Atlantic boulevard and Telegraph road, Los Angeles, has removed its pattern room from the main foundry building to afford additional molding floor space.

Dixie Foundry Co., Cleveland, Tenn., has let the contract for steel for rebuilding its burned foundry to Converse Bridge & Steel Co., Chattanooga, Tenn.

Alco Brass Foundry Inc., 5811 Wilmington avenue, Los Angeles, has been incorporated with $10,000 capital by Allen and Sara Cohn, George W. and Earl C. Heiser.

Precision Machine & Foundry Co., Calgary, Alta., will start work in the spring on the erection of a foundry. Foundry equipment and tools will be purchased.

The National Foundry Co., Erie, Pa., has purchased the assets of the Williams Foundry & Machine Co., Akron, O. The business of the Akron company will be moved to Erie.

National Bearings Metal Co., Norfolk, Va., plans the construction of a plant addition for the manufacture of brass castings and bearing metals.

Northside Pattern & Foundry Co., 3616 Colerain avenue, Cincinnati, has been organized to succeed the Buckeye Pattern Works. The new company has erected an addition for the manufacture of bronze and aluminum castings.

Crown Brass Mfg. Co., which took over the Los Angeles Brass Foundry last August, has consolidated the two plants at 1535 East Sixteenth street, and has discontinued the use of the later name.

Michigan Valve & Foundry Co., 3631 Parkinson avenue, Detroit, has been incorporated by Willard F. Rockwell, with 5000 shares no par value stock to engage in a general foundry and metal manufacturing business.

Union Malleable Mfg. Co., Ashland, O., has completed plans for the construction of a 2-story addition to its plant. The new addition will house additional machinery and shipping space. Lawrence N. Russell is the architect.

The Dayton Malleable Iron Co., plant in Canton, O., which has been closed for two years, will reopen shortly. The plant is one of a group operated through general offices in Dayton. Castings for automobile axles will be the major product.

The Los Angeles Valve & Mfg. Co., 1650 North Indiana street, Los Angeles, has been incorporated with $250,000 capital by A. W. Warr, B. F. Miller Jr., J. B. Roof and E. M. Buckius, all of Los Angeles, to succeed the Los Angeles Valve & Fittings Co. It is understood that the new company contemplates an expansion of the scope of its business.

Daniel Pennebacker, Allentown, Pa., founder of the Pennebacker Foundry Co., Emaus, Pa., has purchased the old Emaus foundry. It has been idle for a number of years. Now it will be used for the making of balls for grinding cement.

American Castings Co. Inc., 6831-43 South Irvington avenue, Chicago, is operating both of their plants 24 hours per day. The company has installed a conveyor system for mold and sand handling and reports business good with fine prospects for the remainder of the first half of the year.

Johnstown plant of the National Radiator Corp. has been awarded a trophy for having the best safety record of the company's six plants during 1928. The National plant had 23 days of lost time during the entire year and at present has a record of more than 180 consecutive no lost-time accident days.

American Brake Shoe & Foundry Co. of California, A. L. Clark vice president and general manager, has purchased 3 acres of land on the north side of Slauson avenue east of the Los Angeles river, Los Angeles, where it will erect a gray iron foundry for the manufacture of brake shoes for steam and electric railways. The present foundry of the company is located at 1179 East Thirty-second street.

Proposed consolidation of three leading farm implement manufacturing companies in the country into one $50,000,000 organization has been announced following a meeting of executives of the companies affected. The merger involves the Oliver Chilled Plow Works of South Bend, Ind., the Nichols & Shepard Co. of Battle Creek, Mich., and the Hart-Parr Co. of Charles City, Iowa.

National Sash Weight Corp., Baltimore, has been organized to take over and consolidate Levering Bros., 200 Key highway, Baltimore, E. E. Brown & Co., Darby, Pa., Carteret Foundry Co., with plants at 2 Pacific avenue, Jersey City, N. J., and Boonton, N. J., and the Borough Foundry Co. Inc., 280 North Henry street, Brooklyn. A committee is arranging the financing of the corporation and plans expansion at the different units.

Headford Bros. & Hitchins Foundry Co., and the Hawkeye Foundry Co., both of Waterloo, Iowa, have been consolidated and the capital stock of the Headford concern has been increased from $75,000 to $200,000 to provide funds for expansion. The combined companies will have an annual capacity of 7500 tons of castings. The officers of the company are: Edward H. Headford, president; Frank O. Hitchins, and William T. Headford, vice presidents; W. E. Robinson, secretary and treasurer.